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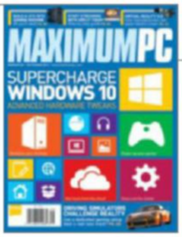

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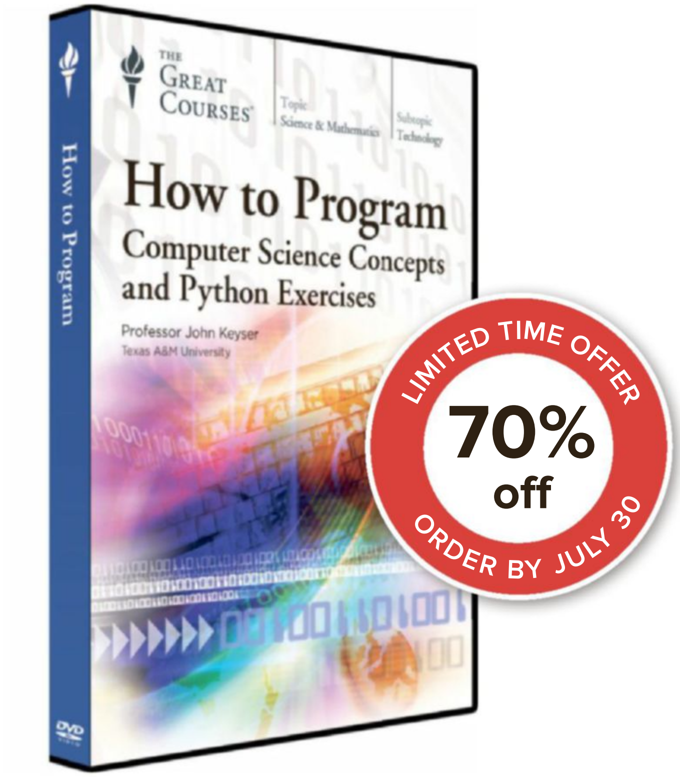

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Tuan
Nguyen

PCS ARE VR-READY, BUT VR ISN'T

BUILDING A PC is much like assembling parts for a high-performance sports car. You've got all the bits and pieces, but there's one critical part that makes everything work together: the ECU, or in the case of our PC, the operating system. And like the ECU in a race car, Windows 10 can be tweaked and locked down to perform better and be more secure.

Ever since Microsoft pushed out Windows 10, there has been a flurry of conflicting opinions about whether or not it is a worthy successor to Windows 7. Yeah, I said 7—we all know how Win 8 performed. But I can tell you definitively that, with the right tweaks, Windows 10 isn't just a worthy replacement, it's better in every essential way.

On my Windows system at home, the Windows installation is separate from my user folder, and all that is then separate from where I install my applications. This ensures everything is organized and there's no cross contamination. The strategy I'm using was more effective when everything was on old hard drives, but it's still good practice even with SSDs.

Aside from hidden tweaks and tricks, which we'll show you in detail, the best way to avoid problems is to pay attention when installing something. More often than not, free programs slyly try to install adware or other components without you noticing. During the installation of any program, don't just click through hastily.

Once your setup is nipped and tucked, you'll be ready to strap on a VR headset and play some games, right? Not really.

I've tried just about every VR headset available. I've even tried VR backpacks that promise to untether you from the risks of tripping-related injuries. I have the final consumer versions of the Rift and Vive. It's definitely exciting to see all the development happening around VR. Unfortunately, the reality of VR is that it just isn't ready. It's still cumbersome and costly. The setup process alone is enough to leave a bad taste in your mouth, and after all is said and done, there aren't any major compelling reasons to stay in VR, aside from the amusement of a few impressive tech demos. Developers haven't figured out a secret sauce to creating a great VR experience, and that's because the two elephants in the room are going about things differently. Oculus wants a sit-down experience, and is pushing developers in one direction, while HTC and Valve are gunning for a room-scale experience.

The application side of VR is heading into murky waters, too: Contrary to previous statements, Oculus is now bent on locking down applications to its own platform. VR was supposed to be an open-platform revolution. At least, that's what we were told from the very pioneers that spearheaded the movement. But that's before it all became big business.

Valve and HTC are still going for the open approach, and right now have a more compelling hardware offering. But each direction has its own caveats, and VR has a long road ahead before it's considered "mainstream." I haven't even touched my Rift or Vive in over a month.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

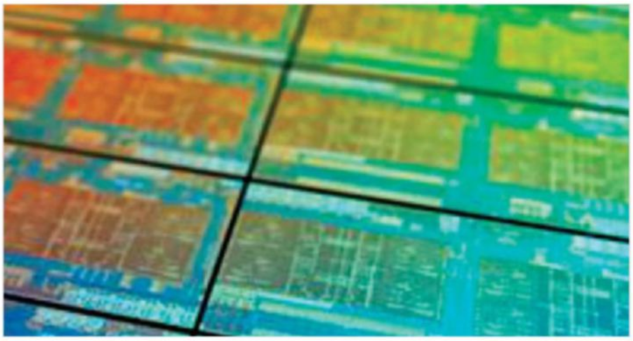
AMD's Zen Core Is Ready to Roll

New high-performance x86 core puts AMD back on the map

AT THE END of AMD's main presentation at E3, we finally got to see its seventh-generation processor in action, as one of its engineers played *Doom* for the crowd. AMD's new Zen architecture core is the company's most important release for years. It's a completely clean-slate design of a high-performance x86 chip, the first since the Bulldozer core of 2011, and will form the basis of a whole family of processors, including Summit Ridge desktops and Raven Ridge APUs.

The design is based on a 14nm simultaneous multithreading microarchitecture, rather than Bulldozer's 32 or 28nm clustered multithread design. This promises up to a 40 percent improvement on instructions per cycle. Much work has also been done to improve power consumption. Each Zen core has four integer and two floating point units, and processors will use between 2 and 32 Zen cores.

The first Zen chip on the market is an eight-core Summit Ridge desktop for "enthusiasts." It employs the AM4 socket, the same as Bristol Ridge. It has support for up to eight channels of DDR4 memory and PCIe 3.0—there is no DDR3 support. Looking at the CPU die images that AMD showed off to its shareholders, it appears to be based on two Zen modules, each with four cores with 8MB L2 caches, a shared 8MB L3 cache, a dual-channel memory controller, and an integrated South Bridge.



AMD shareholders got to see the new Summit Ridge silicon first—each chip clearly sports two Zen modules.

Engineering samples are doing the rounds, and early performance reports are very encouraging, AMD released a simple graph that shows each Zen core being equivalent to two Piledriver cores (second-generation Bulldozer). There are no hard and fast figures yet, but indications are that the new Summit Ridge will be on a par with Intel's i7-5960X Extreme—so pretty fast, then.

Exactly when we will see the first Zen-based chip remains to be seen. Initially, the first Summit Ridge version was due this October; however, this has apparently been put back until early next year, although rumor has it that we may still see some high-end versions slipping out this year.

It's a busy time for AMD, as it has just released details of its next graphics card family, based around the 14nm Polaris GPU. There's the Radeon RX 480, a mid-range card aimed at the VR market; the RX 470, more price/performance conscious; and the more modest RX 460. There are also new Bristol Ridge mobile APUs, featuring Excavator processor cores and Radeon R7 graphics.

> “
> The first Zen chip is an eight-core Summit Ridge desktop for "enthusiasts."

A fair fight

Whole new chip architectures don't come along very often, and they're a big deal—get it right, and you have years of competitive processors. After some time in the shade, it looks as though AMD is back as a serious contender. We haven't seen such healthy competition since the days of the Athlon. In fact, the Zen design comes from a team led by the same CPU architect, Jim Keller, as was behind the Athlon project.

Intel might well have good cause to be worried; Zen-based chips will compete directly with its Skylake chips for price and performance, and provide stiff competition for Kaby Lake, the next architecture after Skylake. Intel is working on a 10nm process chip, but nothing is expected until next year.

Expect much excitement and frantic benchmarking of engineering samples when the hardware does arrive, along with Intel and AMD fanboys resuming their back and forth arguments over which is best. Happy days. **–CL**

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MICROSOFT BUYS LINKEDIN

Its biggest acquisition yet, at $26.2 billion

IN A DEAL that has surprised many, Microsoft has bought LinkedIn for the princely sum of $26.2 billion, which equates to $196 a share, a full 50 percent premium on the share price at the time of the announcement. LinkedIn is hugely popular, but not profitable, reporting an annual loss of $166 million in 2015.

The deal has left many a little puzzled. LinkedIn makes the bulk of its money by selling its recruiting service to corporations that are looking to hire. It has singularly struggled to earn much from paid subscribers or advertising. How Microsoft can earn back its investment looks unclear—it has paid a hefty $60 for every LinkedIn user. The deal does bring the company a lot of data to mine, and some opportunities for integration, but the more immediate benefits are unclear.

Microsoft has a mixed record in acquisitions; its $6.1 billion purchase of Nokia in 2014 proved a failure, written off a year later. It famously wanted to buy Facebook for $15 billion, but was rebuffed. This time, it has acquired a big slice of social networking real estate. As the computer business moves away from straight applications and operating systems toward the cloud, mobiles, and social networks, this fits. However, the price paid hardly looks prudent, particularly given LinkedIn's reliance on stock-based compensation. Its shareholders must be happy now, at least.

Microsoft does have a huge pile of cash to play with, of course—about $92 billion—so win or lose, it can afford it. Meanwhile, there is considerable speculation as to exactly how it will integrate LinkedIn with Office, Bing, and the like, and what is in store for LinkedIn's 433 million users, who will now presumably be pushed toward Microsoft services. **–CL**

VR GOES 4K

GAMES AND HARDWARE APPROACHING RAPIDLY

VR IS ON A ROLL. Sony's $399 PlayStation 4 VR headset is due mid-October. It will work with all PlayStation 4s, and 50 games will offer support by the end of 2016. It runs at 120fps and 120Hz. More importantly, Sony has the VR-friendly high-res PlayStation Neo in the pipeline. It was expected to announce its launch at E3, but it looks like we'll have to wait a little longer.

Not far away either is Microsoft's Project Scorpion: a 4K VR Xbox due next year. Razer has also launched a new $399 VR headset, the HDK2, Hacker Development Kit, for its open-source VR platform. The pricing is the vital element here, undercutting both the Rift and the Vive, while offering the same core specifications.

We now have a generation of hardware arriving from players that can deliver affordable and capable VR, and game support is following. E3 was awash with VR games from franchises such as *Batman, Star Wars, Doom, Fall Out,* and *Final Fantasy,* both wowing and nauseating attendants. By this time next year, VR should be spoiling us for choice. **–CL**

NEW GENERATION OF CORTEX CHIPS

4K and slow motion

ARM
ARMCORTEX A72

INSIDE ALMOST EVERY decent smartphone is an ARM processor; it has an enviable grip on the market. ARM doesn't produce any silicon itself, but licenses its designs to plenty of big players. The company has just announced a major upgrade, too, with the release of the Cortex A72. According to helpful ARM bar graphs, it promises to be up to 3.5 times faster than the A57.

The base architecture is the same as the A57, but it has been shrunk, streamlined, and optimized, with notably better branch predication, lower latency execution units, and faster L2 cache. The key in this sector is power consumption, and here the 16nm A72 addresses the weakness of its predecessor, claiming to be up to 75 percent more efficient. The interesting result of all this is the ability to capture 4K video at 120 frames per second, high-resolution, slow motion—quite a feat for a phone CPU. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

SPAM KING GOES DOWN

A man known as the Spam King, who admitted to sending tens of millions of spam messages on Facebook, received a 30-month sentence.

REMEMBER ATARI?

It's announced it's getting back into hardware, and the Internet of things. You can relive its glory days with 100 classic games on Steam.

FREE SKYRIM UPGRADE

A remastered version of *Skyrim,* with enhanced graphics, is available for existing PC players for free.

TRAGEDIES

MICROSOFT KINECT DEAD

You won't find a Kinect port on the new Xbox One S; it's due to be pushed off to the USB port. It was fun, but never made a good games controller.

STEAM MACHINE UNWELL

While half a million sales sounds like a lot, it isn't for a console. The future of the Linux-based box looks shaky.

RANSOMWARE ON YOUR TV

As TVs get smarter, they also get vulnerable. It appears the ransomware program FLocker has support for smart TVs now.

Dave James

TECH TALK

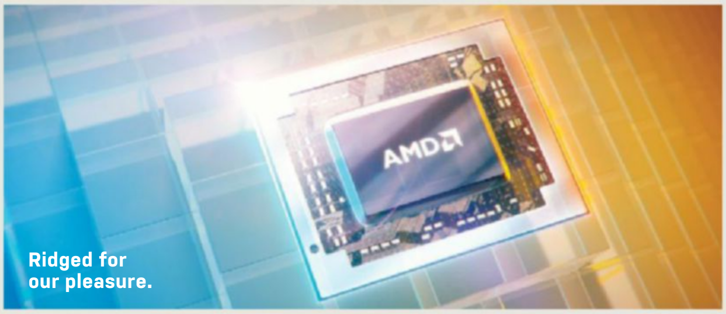
AM4: One Socket to Rule Them All?

DESPITE THE IMMINENT ARRIVAL of AMD's new Polaris graphics architecture, the world is also talking about the company's processors again. And not with a sense of schadenfreude, but with genuine interest and excitement. So with the new AM4 socket set to form the basis of AMD's processing future, why should we care?

One of the reasons I'm excited by the prospect of AMD's new socket and Zen microarchitecture is because it has the feel of classic AMD stuff. I'm not talking about the Bulldozer *et al* days of over-promising on barely-iterative new technologies—I'm talking about taking risks and having interesting new takes on where it can take processing technology.

The new AM4 socket is the base for its upcoming Zen architecture, with the potentially powerful eight-core, 16-thread Summit Ridge in the vanguard of its high-performance new desktop range. It's also the base for its new Bristol Ridge APUs. Historically, AMD and Intel have segregated their motherboards between high-end desktop (HEDT) chips and CPUs with integrated graphics. Not so with AM4.

It manages that by putting even more logic on to the processors—removing the southbridge from the motherboard and placing all those interconnects into the CPU. All your PCIe lanes, SATA, and USB connectivity will be routed through the processor, along with the integrated DDR4 memory controller. It was AMD bringing the memory controller on to the CPU, with the Hammer architecture, that cemented its place as a key player in microprocessors, and it feels like AM4 could be another turning point.



Ridged for our pleasure.

There is resistance, though. Not least from motherboard manufacturers, who have almost become hamstrung, with ever more logic going on-die; only being able to differentiate their products on price and features, rather than performance. But there is resistance from end users, too; some seeing the idea of cheaper motherboards only serving to give AMD an excuse to charge artificially high prices for its CPUs, and others seeing it as locking down users into rigidly segmented areas, taking away build choices. No cheap processors paired with fully-featured motherboards any more; it's AMD's way or the highway.

> No cheap processors paired with fully-featured motherboards; it's AMD's way or the highway.

But choice has to remain. It's not like there will be only one AM4 board created by each manufacturer, some sort of one-size-fits-all generic-o-board. You'll still get some with more SATA and USB sockets, or more PCIe slots for your GPU or SSD. The likelihood of having an AM4 motherboard with a new A12 Bristol Ridge APU, but rocking a bunch of USB ports or PCIe slots you can't use, seems low. There's also been no official confirmation manufacturers won't be able to add third-party controllers on to the boards themselves in some way.

AMD will still deliver choice, then, especially with such a clear upgrade path coming from simplifying its offerings down to a single socket. And I'm also excited about motherboards with such little logic that the mini ITX brigade might well be falling over themselves to build with them. We just have to hope those claims of greater than 40 percent IPC uplift actually come to pass, and we can finally put to bed the miserable days of Bulldozer.

Dave James has been building and writing about PCs and their components for the last two decades.

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Alex Campbell

OPEN SOURCE

You Need to Encrypt Your Laptop Right Now

THERE AREN'T TOO MANY ARGUMENTS for encrypting a desktop that's inside your home. The case for encrypting your laptop, however, is stronger by several orders of magnitude. Encrypting your laptop and mobile devices is one of the smartest moves you can make, and you can do it on the cheap with open-source options, as well.

Imagine this nightmare scenario: You're a grad student working on your master's thesis at a hip cafe downtown. It's getting a bit crowded, but you realize that third cup of tea has made you need to pee. You get up in a hurry, and rush to the bathroom, nearly flattening a toddler, and smashing into a another patron who is miraculously wearing earbuds, holding two coffees, chewing gum, and texting all at once. After you come out of the bathroom, relieved, you find your laptop is gone.

You begin to think about having to re-write those four pages of your thesis that hadn't been synched, while you simultaneously fantasize about finding the rat bastard who stole your PC. That rage turns to panic, as you realize that your tax returns, email history, and Evernote database are on the laptop.

This, sadly, happens all too often in cafes and on university campuses all over the country. Many times, laptops are stolen for the machine's value, not the data. But what if someone wanted the sensitive data stored on the laptop? This happened recently to an NFL executive, who had players' personal information on his PC. If data is what the thief is after, device encryption can save you. Luckily, open-source device encryption software exists.

Encryption Options
VERA CRYPT

It's a good idea to start with a clean slate. I like to back up all of my data to an (encrypted, if necessary) external drive. If you're going to be installing Windows again, use the Media Creation Tool to create a Windows install USB drive. Boot to an Ubuntu live USB, and delete all the drive's partitions with Gnome Disk Utility. (Search for "Disks.") If you're using an SSD, you'll want to make sure to clear all the cells on the SSD. There's a great how-to on the Arch Wiki (https://wiki.archlinux.org/index.php/SSD_memory_cell_clearing). From there, it's usually OK to get started with your system installation, although you can use "shred" or "dd" with "if=/dev/urandom" to overwrite your HDD with random numbers if you're paranoid.

If you're going with Ubuntu or Debian Linux, the installation process prompts you and asks whether you'd like to use full-disk encryption. (In Linux, the /boot partition has to remain in the clear, to make booting possible.) Setting up disk crypto can get a bit more involved if using a distribution such as Arch, or if you want to use a removable USB drive as a boot key.

For Windows, you have a couple of options. Professional and Enterprise versions of Windows come with Microsoft's BitLocker, which can enable whole-disk encryption. If you're uneasy about letting Microsoft manage your keys, you can use VeraCrypt instead. (VeraCrypt is the successor to TrueCrypt.) VeraCrypt's full-disk encryption requires you to install Windows on an MBR partitioned drive, instead of EFI. You can force this mode by choosing "Legacy" mode for your storage in your BIOS.

When software allows it, be sure to write random data to all of the unused blocks on the encrypted drive. It's also important to remember that as long as your machine is powered on and booted, your data is still accessible. Device or full-disk encryption is only a part of an overall data encryption and security scheme (along with things such as secure passphrases). Lost data is bad, but stolen data is worse.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

THE MOST IMPRESSIVE AAA GAMES FROM E3 2016

8

DEATH STRANDING We have little more than an eerie trailer for Hideo Kojima's latest, but we're smitten.

7

CALL OF DUTY: INFINITE WARFARE Space isn't an obvious fit for *CoD*, but it's shaping up well.

6

STEEP Ubisoft's open-world racer pits you against a mountain using skis, snowboards, wingsuits, and more.

5

FORZA HORIZON 3 Every first-party Microsoft game will hit Win 10, including *Gears of War 4* and *Halo 6*.

4

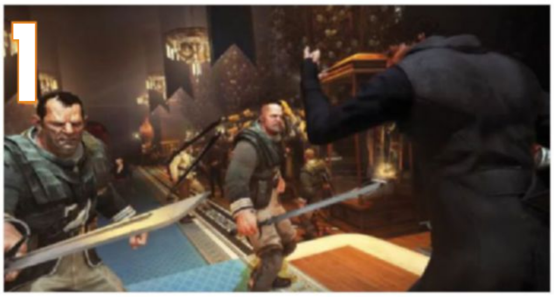
RESIDENT EVIL 7 Jump scares aplenty in the demo that sees the series return to its scary roots.

3

GHOST RECON: WILDLANDS Cause mayhem with up to three friends in this open-world sandbox.

2

BATTLEFIELD 1 Back to WWI for 64-player battles. A Zeppelin going up in flames has us all kinds of stoked.


1

DISHONORED 2 We're fans of the original, and can't wait to return to Dunwall for this stunning-looking sequel.

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TALKING

BY ZAK STOREY

AMD Explains Why Polaris is Important for VR

Maximum PC speaks to AMD's Roy Taylor about VR, and the potential of its new architecture

Virtual reality: Those two words are on the lips of every techie and journalist inside and outside the industry. Yet VR is not without its flaws. We spoke to AMD's Roy Taylor to try to understand what the big companies are doing to counter the current problems, and exactly what the future holds for this innovative and exciting new field of display technology.

Roy Taylor, AMD's kingpin of VR, tells us exactly what we'll need to push VR forward.

Maximum PC: We're here with AMD's Roy Taylor, corporate vice president of Alliances, Content and VR. Roy, I've got to ask: The vast majority of our audience is certainly concerned about VR's uptake—after all, even with pre-sales reaching into the tens of thousands, it's still chump change for any game developer or mainstream publisher—so, what do you reckon it will take to make VR a success?

Roy Taylor: Well, that's a very good point about the install base and the size of the market. John Peddie Research says that if you look at the minimum spec—a Radeon R9 290 or GTX 970 or above—the total install base of those is 7.5 million units. Now, that was information from toward the end of the year, so the number's gone up since then, but it's a problem because, assuming that all of those can be matched with headsets—and that's going to take a little bit of time—that's still not that big enough of a market for some of the games publishers to come out and invest. When I say invest, I mean invest in something really, really tent pole. So, what we've gotta do is one of two things: Help prime the pumps—you know, invest in the game developer community, so they can make the content now, without waiting for the total available market to grow—and also help grow the total available market, by producing new graphics products, at new lower price points, that will run the minimum specs. And we're looking to do both.

MPC: So, is that what your aim is with Polaris?

RT: Yes.

MPC: With the specs so tightly locked for both the Oculus and Vive, is there any room for graphics manufacturers, like yourselves, to step in with their own technologies, say FreeSync displays for the HMDs?

RT: Well, there could be, but I know that we don't have any plans to make a headset. And the reason for that is that we're aware of so many coming already. There's more than 40 other headsets on their way. And what we think is going to happen is two things. First of all, there's going to be an arms race toward higher resolution headsets. Now, we already have a 4K headset—it's absolutely beautiful, it runs at 120Hz in our labs—so we think there's definitely going to be a rush toward higher resolutions. At the same time, we're aware of new headsets coming along, and the quality is very good, and the price points are fantastic. So, there's a Chinese headset manufacturer called Dee Poon, for example, that makes a good headset; we're also excited about Sulon, who we're working with; and Star VR, who has

Oculus is the icebreaker, but with 40 other headsets coming up, it won't be the only one swinging that VR banner.

RADEON
RADEON

Polaris was designed with VR in mind. The RX 480 pricing should make VR more accessible.

great headsets, too. What's important, however, is that for those headsets that don't have controllers there is a healthy, vibrant controller market, so we're very pleased with the work that Sixense is doing. We don't have any direct interaction with Sixense, because it makes controllers, but we think that its success is important to the overall growth of the VR market. So, we don't need to make our own headset, we don't want to compete with the people we're partnering with, and we don't think it's necessary.

MPC: Last year saw the announcement of Razer's OSVR. Can you tell us how AMD is involved in championing this new standard of open-source technology? What does it mean for the VR playing field?

RT: Yeah, we think OSVR is important, because it'll allow a common playground for independent headset manufacturers and independent controller manufacturers to come together, so we applaud them for the work they've done. We're supporting them, we're part of their association, and I'm very pleased to tell you that they are integrating our Liquid VR into OSVR, and we're giving them all of the tools that they need for them to do that.

MPC: What challenges do graphics manufacturers face when it comes to the demanding fps resolutions of head-mounted displays? How is AMD overcoming these problems?

RT: Well, there are a lot of problems to be solved. You know, if you look right now at where we're at, the current performance of VR is around 2K per eye, at around 10ms of latency, and around 90fps. That's roughly equivalent to about 8 TFLOPS of performance, which is roughly comparable to our current highest-end graphics cards, and those of our competitors. What we want to get to is 16K per eye, at around 144fps, and zero latency. That's roughly equivalent to 743 TFLOPS, or 81 times more performance than we have now. So, we've got a lot of work to do to keep building bigger, faster, high-performance GPUs, with world-class drivers, and next-generation software—LiquidVR 2.0, LiquidVR 3.0—to keep making the creator's job easier.

MPC: Is that something that Polaris's 14nm FinFET process will be able to manage—or at least put us on the right path toward?

RT: Yes, Polaris has been designed from the outset with VR in mind. You've gotta remember that asynchronous compute, which is on our GPUs, was thought of some years ago. We have a brilliant ASIC design engineer called Mike Mantel, and Mike had the idea that we would, at some point in the future, want a GPU that could do multiple jobs simultaneously, without having a traffic jam, so he came up with the concept called asynchronous compute—that was some time ago. Asynchronous compute is absolutely essential for smooth frame rates in VR in DX12, and DX11.

MPC: You'll have to forgive us—we have to ask. Polaris: How is it looking? Is there anything you can give us at all on this one? This year's going to be a doozie for GPUs—I think everyone is excited—so is there anything you can tell us about it?

RT: Unfortunately, we're in our quiet period at the moment. I wish we could provide more but, unfortunately, there's only everything we've already said, and we're just really excited about it coming to market. We do think the importance of 14nm FinFET cannot be underestimated, though. Current GPUs from ourselves and our competitors are 28nm—when you shrink, the interconnects are closer together, and because they're closer together, they run faster. Also, because they're closer together, they use much less power, and you can also get more per wafer. So that's not telling you anything that hasn't already been stated, but that's not to say you can't put together just what that means.

MPC: Thank you very much for your time, that's very insightful.

RT: It's been a pleasure.

DOCTOR

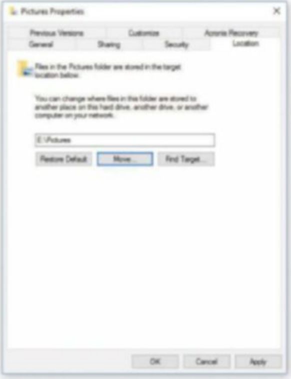
THIS MONTH THE DOCTOR TACKLES...

> Protecting Power
> Win 7 and Skylake
> Battlefield Plans

Protect Your Power

Hey Doc! Finally, after saving for six months, I built my first PC with a Core i5-6600K CPU, Gigabyte Z170X-Gaming 7 motherboard, Radeon R9 390 graphics card, 600W 80 PLUS Bronze-rated power supply, and 16GB of DDR4 memory. I live in an old house, though, and I worry that the number of blackouts we experience will damage my new hardware. Do you have any suggestions? **–Ben Danielson**

THE DOCTOR RESPONDS: Unstable power can be hard on your PSU and the equipment attached to it, so you're right to be concerned. Power is lost completely during a blackout, and although blackouts can last days, all it takes is milliseconds for whatever you're working on to vanish. Worse, problems with power can torpedo the voltage regulation circuitry on sensitive components, curtailing their useful lives.



Files in the Pictures folder are stored in the target location below.

You can change where files in this folder are stored to another place on this hard drive, another drive, or another computer on your network.

E:\Pictures

Redirect the Pictures folder to optimize tiered storage, moving user data to mechanical disks.

Knowing that your electrical infrastructure may be flighty, consider an uninterruptible power supply, which kicks in whenever there's a disruption. Entry-level UPS systems use offline/standby technology, switching to a built-in battery if input voltage falls too low or spikes. Higher-end models feed attached hardware continuously through the batteries, which constantly charge unless power is lost. But while these online/double-conversion systems isolate your hardware from dicey mains electricity, even the cheapest implementations are still expensive.

A reputable offline/standby unit should provide plenty of protection against blackouts, incorporate surge suppression, give you a few minutes to power down your PC if the power doesn't come right back on, and only set you back $100–$200.

Build Advice

I'm no geek. Rather, I'm a simple merchant seaman, but I'm upgrading my eight-year-old son's PC, and recently purchased the following:

1) *MSI 970-based motherboard;*
2) *AMD FX-4130 CPU;*
3) *MSI GeForce GT 610;*
4) *Samsung 850 EVO 250GB;*
5) *Kingston HyperX DDR3-2133 8GB memory kit;*
6) *Artic Freeze 7 Pro CPU cooler.*

I'm hoping this will all fit into an old HP Pavilion a1430n tower, with upgraded fans, and maybe a new PSU. How have I done? He is a huge *Minecraft* fan. Have I let him down? Feel free to rip into me; I can take it. And thank you for your time. **–John M.**

THE DOCTOR RESPONDS: For the most part, that's a balanced entry-level system, capable of satisfying *Minecraft's* requirements. Where it'll run out of steam first is the GeForce GT 610. More than four years old, it's at the bottom of a three-generation-old family. Should your son and his friends get permission to dabble in newer, more demanding games, the 610 won't be fast enough. Stepping up to something like the GeForce GT 730, with GDDR5, for less than $70, gets you 384 CUDA cores, and a far more enjoyable experience.

Double-check the fitment of the motherboard, too. HP's a1430n looks like it fits micro-ATX mobos, and the Doc doesn't see any 970-based platforms from MSI in that form factor.

Redirecting Folders

I must be the oldest (72-year-old) *Maximum PC* reader—I was introduced to the magazine in 2011. Since then, with the knowledge I've acquired, I have built five PCs. The newest sports a Z97-based motherboard, an Intel Core i7-4790K CPU, two 250GB Samsung 850 EVO SSDs in RAID 0, and an EVGA GeForce GTX 980 Ti, all crammed into a white Corsair 760T case. With Windows 10, this machine really purrs. But I have a problem with one of my storage settings. I've redirected my Documents, Videos, and Music folders to a 2TB hard drive, attached via SATA. However, I can't move the Pictures folder. I don't want my pictures saved to the SSDs. Please help. **–Michel Cauvin**

THE DOCTOR RESPONDS: On behalf of the team, thank you for your patronage. Your system indeed sounds like a beast, and the Doc agrees that moving user data off solid-state storage is the right way to go in a tiered configuration.

Without more information about the error you're seeing,

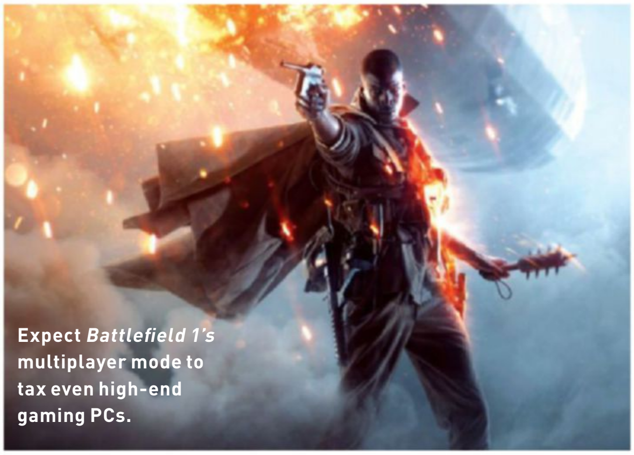
↘ submit your questions to: doctor@maximumpc.com it's hard to know why three of your "Quick Access" folders could be moved, while a fourth can't. Just to make sure you're following the same procedure as the Doc, verify the following:

Open File Explorer. Click "This PC" on the left. That should bring up a number of folders, devices, and drives, one of which is Pictures. Right-click the Pictures folder, and select "Properties." Select the "Location" tab. The path listed is where pictures are being saved. To move it, click "Move." Navigate to your mechanical disk, create a new folder if needed, and press "Select Folder." After clicking "Apply" on the Pictures Properties window, you should get a pop-up asking you to confirm that you want to move everything from the previous location to the new one. Click "Yes."

Win 7 and Skylake

Doc, please provide an update on Microsoft's FUD about not providing Windows 7 patches for Skylake-based CPUs. Recently, the company sounds a bit less draconian, but initial statements made it sound like a big mistake to put Windows 7 on current-gen hardware beyond 2017, even though Microsoft continues saying it'll provide patches until Windows 7 is EOLed in 2020. Also, your advice would be appreciated about Win 7 support of M.2 drives—AHCI and NVMe. Will that support get more consistent? Any guidance about when those devices do and don't work? **–Gregory A. Miller**

THE DOCTOR RESPONDS: Back in January, Microsoft published a blog post announcing that support for Skylake-based platforms running Win 7 would cease in July 2017, despite the fact that the OS's extended support isn't scheduled to end until January 2020. Beyond 2017, Microsoft said its coverage of Skylake/Win 7 would be limited to critical security updates, providing they don't compromise reliability or compatibility. This revelation was met with much consternation among enthusiasts. Based on the response, Microsoft revised its position this past March, extending support for Skylake on Windows 7 and 8.1 until July 17, 2018. After that, you'll only receive critical updates.

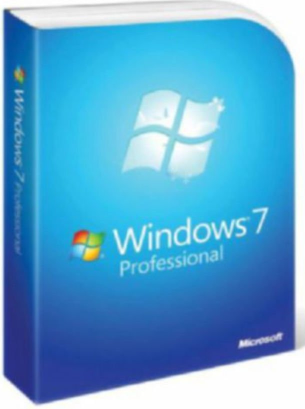


Expect *Battlefield 1's* multiplayer mode to tax even high-end gaming PCs.

Unchanged, however, is the company's take on next-gen hardware. Intel's upcoming Kaby Lake processor family and AMD's Bristol Ridge APUs will only be supported under Windows 10. If you're planning an upgrade, expect Windows 10 to tag along, welcome or not.

As for storage support in Windows 7, it's hard to imagine motherboard, SSD, or software vendors putting additional effort into an older operating environment. As the ecosystem stands, there's enough variance in how boards and drives work together to warrant model-specific guides in a number of forums and manufacturer support pages. Your best bet is plenty of homework prior to building a PC with Windows 7.

Enthusiasts still love Windows 7, but Microsoft is eager to discontinue support.



Battlefield Plans

I built my gaming rig in 2013 for *Battlefield 4*, with an Intel Core i5-4670K, Radeon HD 7970, Gigabyte GA Z87X UD4H motherboard, 16GB DDR3 RAM, a 256GB SSD, two 640GB hard drives in RAID 0, and a Corsair CMPSU-750TX 750W PSU. Is it worth building a new rig for *Battlefield 1*, or should upgrading my video card suffice for DX12/future-proofing?

–Matt Spector

THE DOCTOR RESPONDS: As of this writing, EA DICE hasn't provided minimum or recommended hardware requirements for *Battlefield 1*, but we do know the game employs the Frostbite engine. We also know it needs to run on Microsoft's Xbox One and Sony's PlayStation 4 consoles.

When *Battlefield 4* launched, DICE recommended a Radeon HD 7870 or GeForce GTX 660. *Star Wars Battlefront* called for a more capable Radeon R9 290 or GeForce GTX 970. It wouldn't be a stretch for *Battlefield 1* to push graphics a bit harder, particularly at elevated quality preset levels on the PC. The Doc says count on a new graphics card, at least.

Whether you need a new CPU depends on your preferred mode of play. DICE's single-player campaigns typically run smoothly on Intel's mid-range CPUs. But as you dip into the large multiplayer maps, host processing takes a bigger hit. The developer already announced plans to include 64-player battles, so play this one by ear. If you get the game and it struggles with the settings you want to use, a platform upgrade might help. Fortunately, even today, your Core i5 is still a solid CPU.

Updating an Old PC

Greetings, Doc. I have a Gateway DX4860 with an Intel Core i5-2320 processor. The motherboard is a Gateway IPISB-VR with 8GB of memory, and the BIOS comes from AMI, version P02-A2, dated 10/31/2011. I recently updated my graphics card to a GeForce GTX 950, too.

Is there a good program I can use to update the BIOS, or would it be better to drop in a Core i7? The system runs fine; it's just slow at times, even though I use Windows 10. The only games I play are *Flight Simulator X* and *War Thunder*. It seems to perform fine in those titles, slowing down more often in *War Thunder*. Thank you for any suggestions you might have.

–Les Johnson

THE DOCTOR RESPONDS: To update your motherboard's BIOS, head to http://us.gateway.com/gw/en/US/content/drivers-downloads and enter your PC's model number in the "Search by Product Model" field. That'll bring up a page with drivers updated through 2013. Click on the "BIOS/Firmware" tab, and you'll find a newer build, version P11.A3 (though the description calls it a UEFI for Windows 8). The ZIP file you download includes a guide to walk you through—there's even a Windows-based option for ultimate simplicity.

A new BIOS doesn't guarantee better performance, though. Your CPU is almost five years old and based on the Sandy Bridge architecture, four generations behind today's Skylake. More important, you made no mention of an SSD. If you don't own one, prioritize solid-state storage next time you think about an upgrade. There's a good chance that'll make the most appreciable difference in performance.

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ADVANCED WINDOWS 10 TIPS & TRICKS

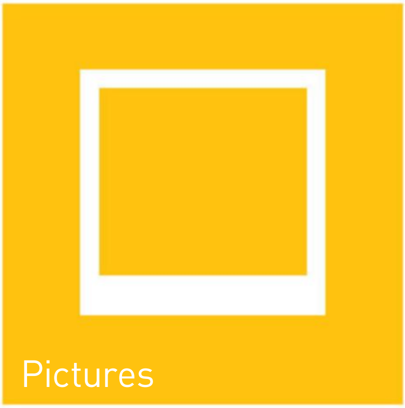
Discover essential techniques and tools to lick Windows into shape with *Nick Peers*

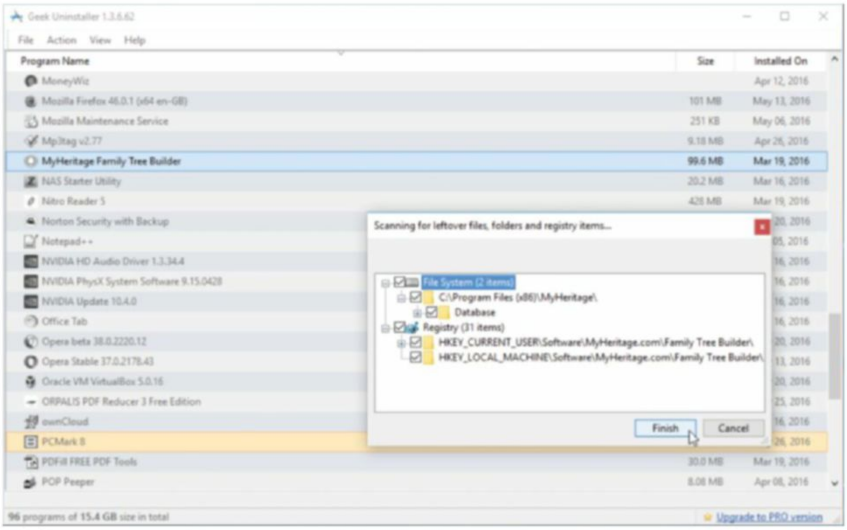
There's no getting away from it: Windows needs almost constant attention. Take your eye off the ball, and it's suddenly clogged up with unwanted files and struggling to keep up, thanks to a pile of software you thought was interesting at the time, but have long since abandoned. Obviously, keeping your PC in good shape is a key part of making it perform well, but while Windows 10 is streets ahead of its predecessors in terms of keeping its demands on your processor, RAM, and other components quite low, there's still lots you can do to fine-tune it, discovering tweaks and settings that ensure it's running at optimum efficiency and speed.

In this feature, we reveal plenty of tips and tricks for making the most of Win 10. We start by giving your PC an efficiency drive—clearing out the rubbish, streamlining startup, and delving into places you may not have thought to cut the bloat and ensure your PC isn't wasting resources on spurious programs and processes. And speaking of bloat, we reveal a handy tip or two for keeping out unwanted programs.

We also show you how to partition your hard drive, and why keeping your data separate is a good idea (it's still no substitute for a backup, though, so keep that in place—check out our guide in the June issue). We then take a closer look at certain parts of your hardware—we remind you why upgrading to an SSD is one of the most effective upgrades you can make, plus reveal some handy tweaks for ensuring it's running smoothly.

If that's not enough, we share some other secrets, too—why portable apps are better than regular installed programs, for example, plus how to tighten Windows 10's lax privacy controls. And if you're about to upgrade to Windows 10, we reveal a path you can follow that enables you to run it alongside your existing version of Windows in a dual-boot configuration. So, get ready to watch your PC take on a new lease of life!





Program Name	Size	Installed On
MoneyWiz		Apr 12, 2016
Mozilla Firefox 46.0.1 (x64 en-GB)	101 MB	May 13, 2016
Mozilla Maintenance Service	251 KB	May 06, 2016
Mp3tag v2.77	9.18 MB	Apr 26, 2016
MyHeritage Family Tree Builder	99.6 MB	Mar 19, 2016
NAS Starter Utility	20.2 MB	Mar 16, 2016
Nitro Reader 5	428 MB	Mar 19, 2016
Norton Security with Backup		20, 2016
Notepad++		05, 2016
NVIDIA HD Audio Driver 1.3.34.4		16, 2016
NVIDIA PhysX System Software 9.15.0428		16, 2016
NVIDIA Update 10.4.0		16, 2016
Office Tab		16, 2016
Opera beta 38.0.2220.12		20, 2016
Opera Stable 37.0.2178.43		13, 2016
Oracle VM VirtualBox 5.0.16		20, 2016
ORPALIS PDF Reducer 3 Free Edition		25, 2016
ownCloud		16, 2016
PCMark 8		26, 2016
PDFill FREE PDF Tools	30.0 MB	Mar 19, 2016
POP Peeper	8.08 MB	Apr 08, 2016

Scanning for leftover files, folders and registry items...

- ☑ File System (2 items)
  - ☑ C:\Program Files (x86)\MyHeritage\
    - ☑ Database
- ☑ Registry (31 items)
  - ☑ HKEY_CURRENT_USER\Software\MyHeritage.com\Family Tree Builder\
  - ☑ HKEY_LOCAL_MACHINE\Software\MyHeritage.com\Family Tree Builder\

96 programs of 15.4 GB size in total

Use GeekUninstaller to remove programs more thoroughly.

Let's start our efficiency drive with Windows itself. Before you begin, take a System Restore point or drive image—if you take a wrong turn, you can then roll things back and start again. To do the former, type "system restore" into the Search box, and click "Create a Restore point"—verify System Restore has been turned on and correctly configured for your system drive (select it, then click "Configure..." to do so).

Right, we'll begin by giving Windows a good clean. Start by removing any programs and Store apps you no longer need—you'll be surprised at how these can build up over time. These can be removed via "Start → Settings → System → Apps & features," but if you want to go the extra mile, and clear out any leftover files and Registry entries, you'll need to employ the services of a third-party tool.

This is a tricky area—the only tool we've found capable of cleaning out both programs and Windows Store apps is IObit Uninstaller (www.iobit.com), but it's a little too aggressive in attempting to get you to install its full Advanced SystemCare Free suite. If you can live with occasional prompts, use its Powerful Scan feature to clear out redundant Registry entries and leftover files. If you're happy to limit scans to regular programs, try GeekUninstaller (www.geekuninstaller.com) instead, which has the added benefit of being completely portable—no installation required.

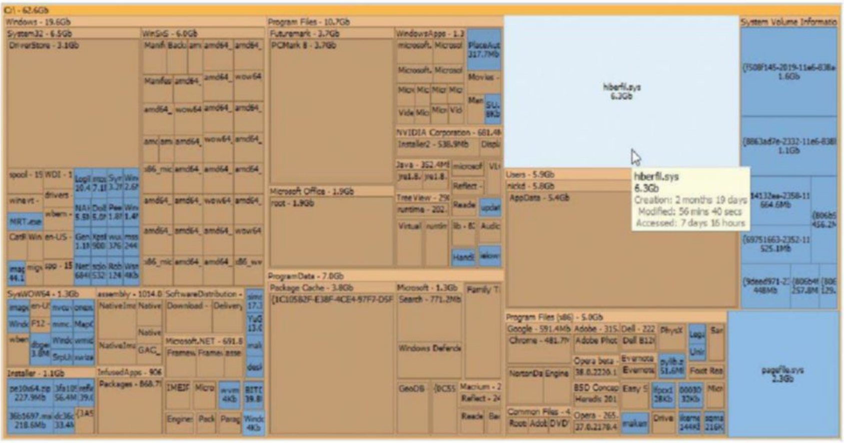
Once you've cleaned things up, turn your attention to programs and services that start with Windows—these don't just lengthen your boot time, but sit in the background consuming resources, too. You can quickly see which are the most resource-hogging startup programs by opening Task Manager from the Taskbar's right-click menu—switch to the "Start-up" tab (click "More details" first, if necessary), and examine the "Start-up impact" column. Target those High and Medium rated programs you don't use that often by right-clicking them, and choosing "Disable."

When it comes to Services, you can manage these yourself via the Services desktop app (type "Services" into the Cortana search bar), using the excellent Black Viper (www.blackviper.com) guide to see which Services you can safely disable. If the idea of manually trawling through these doesn't appeal, download the portable Easy Services Optimizer tool from www.sordum.org/8637/easy-service-optimizer-v1-2/. Read the guide carefully, but—simply put—choose "Safe" or "Tweaked" for a quick-fire range of optimizations that will speed up your PC, but may introduce problems. Use the program's own "Service → Reset Service List" option, or a Restore point, to undo your changes if necessary.

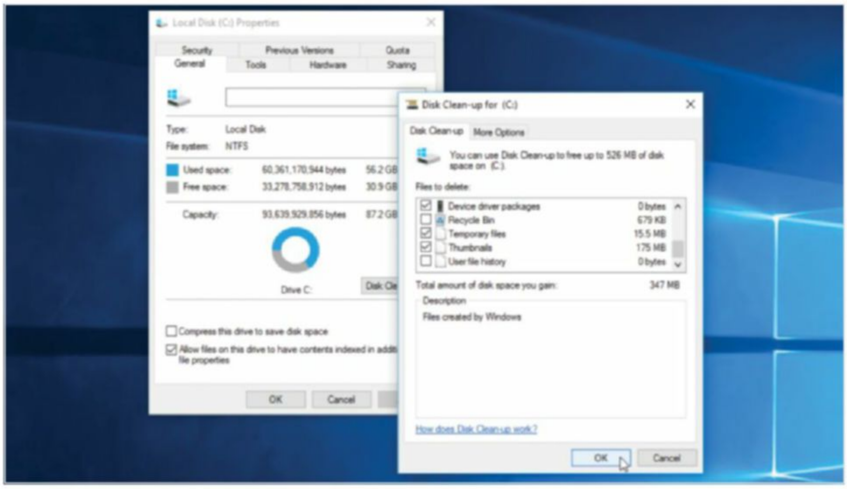
Many programs and apps continue to run in the background after you close them—check for a program icon in the Taskbar's Notification Area (click the "^" button to view the full list), or select "Start → Settings → Privacy → Background apps," and flick the switches to "Off" for all or any apps you want to close fully when not in use.

Clean out your drive

The next step is to reclaim wasted hard drive space—even if your drive isn't bursting at the seams, it pays to keep things neat and tidy. Open File Explorer, right-click your system drive (the one marked with the Windows logo), and choose "Properties." Click "Disk Clean-up" on the General tab, and as soon as it opens, click "Clean up system files," to ensure all options are shown. Work through the list, ticking those items you don't want—the biggest gains often come from previous


C:\ - 62.6Gb
Windows - 19.6Gb
Program Files - 10.7Gb
hiberfil.sys
6.3Gb
Creation: 2 months 19 days
Modified: 56 mins 40 secs
Accessed: 7 days 16 hours
pagefile.sys
3.3Gb

Find out what's taking up all your drive space with SpaceSniffer.


Local Disk (C:) Properties
Security
Previous Versions
Quota
General
Tools
Hardware
Sharing
Drive C:
Disk Cle
OK
Cancel
Disk Clean-up for (C:)
Disk Clean-up
More Options
How does Disk Clean-up work?
OK
Cancel

Type: Local Disk
File system: NTFS
Used space: 60,361,170,944 bytes 56.2 GB
Free space: 33,278,758,912 bytes 30.9 GB
Capacity: 93,639,929,856 bytes 87.2 GB

☐ Compress this drive to save disk space
☑ Allow files on this drive to have contents indexed in addi file properties

You can use Disk Clean-up to free up to 526 MB of disk space on (C:).

Files to delete:

☑	Device driver packages	0 bytes
☐	Recycle Bin	679 KB
☑	Temporary files	15.5 MB
☑	Thumbnails	175 MB
☐	User file history	0 bytes

Total amount of disk space you gain: 347 MB

Description
Files created by Windows

The Disk Cleanup tool removes some unwanted data, but not all.

Windows installations and system dump files. You can free up space by deleting System Restore points, too, from the More Options tab, but only do this as a last resort, if you're desperate for space.

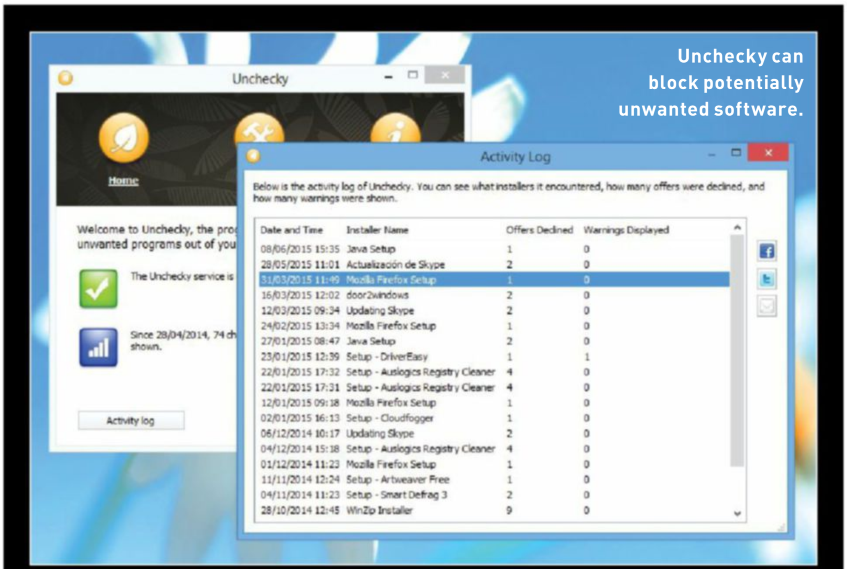
If you want to push the envelope further, download and install CCleaner from www.piriform.com/ccleaner/builds—you'll find a portable version here if you'd rather not install it. The Cleaner component can sweep through Windows, browsers, and application caches to recover gigabytes of files at a time, but it pays to review each item first—you'll lose cookies, Jump List entries, and other useful shortcuts if you're not careful. Click "Analyze," and you'll see a list of what's found—right-click an entry and choose "View detailed results" to see exactly what's getting cleaned, then right-click items you want to keep, and choose

"Add to Exclude list" to protect them from being cleaned now and in the future.

CCleaner has a Registry cleaning tool as well—long story short, leave it well alone. Registry cleaners don't improve performance, and usually introduce more problems than they solve. You might get minor joy using a Registry defrag utility to rearrange the Registry hive files in a similar way to your hard drive, but performance gains are minimal—use Free Registry Defrag (www.registry-clean.net/free-registry-defrag.htm) if you want to go down this route; it works fine with Windows 10.

If you're wondering what's taking up all the space on your hard drive, check out a free portable tool called SpaceSniffer (www.fosshub.com/SpaceSniffer.html), which presents the files on your hard drive using the Treemap concept. Run it as an administrator, to give it access to all your files, then focus in on the biggest folders, to see where the large files are hiding away. It's also worth checking your drive for unnecessary duplicate files—CCleaner can do this for you via its "Tools → Duplicate Finder" component.

One large file SpaceSniffer is likely to identify is hiberfil.sys—it's usually the same size as your RAM, because it's where the contents of your memory are stored when you hibernate your PC. If you never use hibernation (sleep doesn't use this file),



Welcome to Unchecky, the prog
unwanted programs out of you

The Unchecky service is

Since 28/04/2014, 74 ch
shown.

Below is the activity log of Unchecky. You can see what installers it encountered, how many offers were declined, and how many warnings were shown.

Date and Time	Installer Name	Offers Declined	Warnings Displayed
08/06/2015 15:35	Java Setup	1	0
28/05/2015 11:01	Actualización de Skype	2	0
31/03/2015 11:49	Mozilla Firefox Setup	1	0
16/03/2015 12:02	door2windows	2	0
12/03/2015 09:34	Updating Skype	2	0
24/02/2015 13:34	Mozilla Firefox Setup	1	0
27/01/2015 08:47	Java Setup	2	0
23/01/2015 12:39	Setup - DriverEasy	1	1
22/01/2015 17:32	Setup - Auslogics Registry Cleaner	4	0
22/01/2015 17:31	Setup - Auslogics Registry Cleaner	4	0
12/01/2015 09:18	Mozilla Firefox Setup	1	0
02/01/2015 16:13	Setup - Cloudfogger	1	0
06/12/2014 10:17	Updating Skype	2	0
04/12/2014 15:18	Setup - Auslogics Registry Cleaner	4	0
01/12/2014 11:23	Mozilla Firefox Setup	1	0
11/11/2014 12:24	Setup - Artweaver Free	1	0
04/11/2014 11:23	Setup - Smart Defrag 3	2	0
28/10/2014 12:45	WinZip Installer	9	0

Unchecky can block potentially unwanted software.

Avoid Bloatware

This guide is all about removing unwanted programs and services, helping free up resources, and potentially providing a noticeable speed boost. But what can you do to stop the flow of bloatware and other potentially unwanted programs (PUPs) from appearing on your PC in the first place? One solution is to purchase a Premium license for Malwarebytes Anti-Malware (www.malwarebytes.org). While the free version can detect and remove PUPs, as well as malware, the Premium version provides real-time protection that blocks them in the first place, often without affecting the rest of the program installation.

If that's too rich for your blood, then Unchecky (www.unchecky.com) is a small program that sits in the background and can detect a wide (if not fully comprehensive) array of adware-infested program installers. It then alerts you to tweak the program installer to de-select any adware options, ensuring you don't accidentally click "Install" before reviewing what else is attempting to get on to your PC. Unchecky isn't 100 percent infallible, but it's a useful extra layer of protection all the same.

Bloatware often makes a return on many PCs when you reinstall using the manufacturer's recovery image. If you've just spent ages meticulously removing this from your system, now's the time to create your own customized recovery image, so when you next reinstall Windows, you don't get all that unwanted software back. Once you've set up your PC as you want it, press Win-X to open the Quick Access menu, then select "Control Panel." When it opens, click "Save backup copies of your files with File History," and choose "System Image Backup" to create a complete image of your hard drive. You can restore this via a Windows recovery drive, or via the Advanced Start-up menu (hold Shift as you click "Start → Power → Restart" to access it).

switch it off, and reclaim that space: Press Win-X to open the Quick Access menu, choose "Command Prompt (Admin)," then type "powercfg.exe /hibernate off" into the command prompt.

Clean out the context menu

One area that can get particularly cluttered is the menus that appear when you right-click items in File Explorer, with programs adding shortcuts of their own. One way to manage these is to manually identify unwanted items when you right-click a particular file or folder, then explore the offending program's own settings for an option to remove the unwanted options.

If you want to remove multiple items in one go, you can either open Registry Editor and browse to "HKEY_CLASSES_ROOT," where you'll need to navigate five different subkeys to find all the offending items, or you can save time by firing up CCleaner, and navigating to "Tools → Startup → Context Menu" for a complete list of options based on directory, drive, and file context menus. Select multiple items using Ctrl-click, then choose "Disable" to temporarily remove them, or "Delete" to get rid permanently.

One often-overlooked area for cleaning is your web browser. How many add-ons are installed? Internet Explorer encourages you to examine and manage these when it detects those that significantly affect

Registry cleaners don't improve performance, and usually introduce more problems than they solve.

startup times, but you can see which plugins and add-ons are installed via your browser's own add-ons screen—how you get here varies from program to program, but Firefox users should type "about:addons" into the Address Bar, while IE users should go to "Tools → Manage Add-ons." If you have multiple browsers, you can also manage these add-ons collectively via CCleaner's "Tools → Browser Plugins" section, where you'll find IE, Firefox, Chrome, and Opera are covered via separate tabs.

Optimize searches

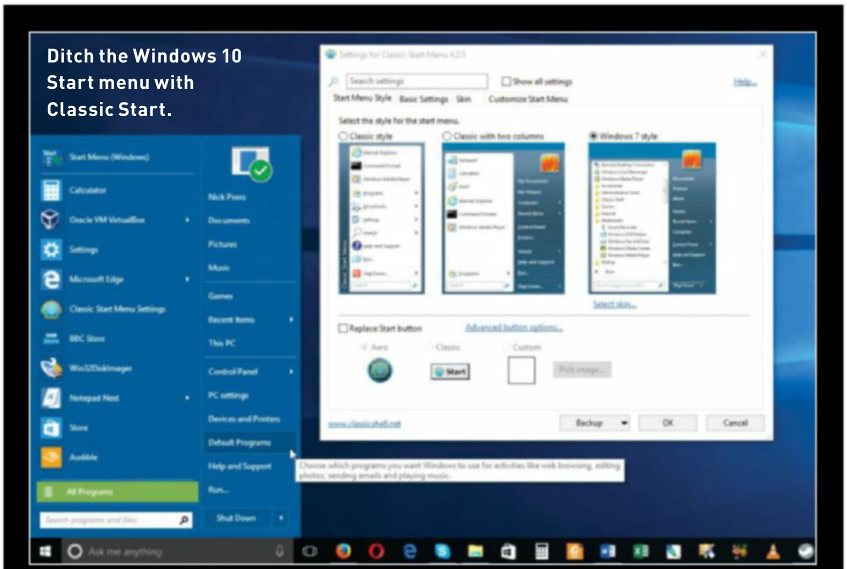
Is Cortana getting on your nerves? Want to limit her influence, or hide her away completely? If the Search box on the Taskbar is distracting, right-click the Taskbar, and choose "Search → Show Search Icon," to replace it with a clickable magnifying glass, or "Hidden" to hide it completely (if you've set up Cortana to respond to voice commands, you can still invoke her using the "Hey Cortana" command).

Hiding Cortana is one thing, removing her requires more work: Click the Search box, then the Notebook icon, and choose "Settings." Flick the top switch to "Off" to disable Cortana. You can restrict the Search box to locally stored results (programs, apps, and files) by flicking "Search online and use web results" to "Off," too. Annoyingly, it's still a two-step process to access the results for personal files—type your terms, then click "Search my stuff."

You can optimize Search in other ways, too: type "search" into the Search box, and click "Change how Windows searches." You'll see which folders have been selected for indexing—click "Modify" to remove unwanted folders (and reduce wear and tear on the drive) by unticking them, plus add others that aren't already in indexed locations, to speed up future searches. Click "Advanced" to perform other related tasks—move the index to another drive, for example, or switch to the "File types" tab to determine which files you want to index, and whether to include the contents (such as text), as well as the properties in the index.

Streamline PC usage

It's not just about making your PC more efficient, you can also speed things up by streamlining the way you use your PC. Get into the habit of using keyboard shortcuts to launch favorite apps, for example—you can manually add these by right-clicking a program's shortcut in File Explorer, and choosing "Properties." Use Alt-Ctrl combinations, or experiment with function keys. You can also quickly launch programs you've pinned to the Taskbar using the Win key plus a number, which launches apps in the order they appear from left to right—


Ditch the Windows 10 Start menu with Classic Start.

Restore Classic Windows Features

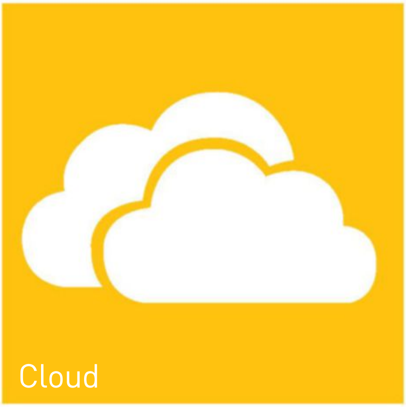
Fed up with certain aspects of Windows 10? Take the Photos app, for instance—if you're wedded to Windows Photo Viewer, you can restore it as the default viewer for your images. If you've just upgraded to Windows 10, head to "Start → Settings → System → Default apps" to select it. Reinstalled from scratch? It's missing, but you can get it back, and the simplest way is through the portable—and completely free—Ultimate Windows Tweaker tool from http://bit.ly/uwt-win10. Once extracted, launch the tool, and head to the "Additional" section, where clicking "Enable Windows Photo Viewer" brings it back, and enables you to set it as default.

Now go to "Customization → Windows 10." You'll find three tweaks that enable you to bring back the old-style battery, date and time, and volume control flyouts in the Taskbar's Notification area—untick the options, and click "Apply."

Can't stand the new Start menu (particularly with its habit of showcasing ads in the form of promoted apps)? You can replace it with a more classically themed menu—either Classic Start (www.classicshell.net) or Start10 ($5, www.stardock.com) will give you a more traditional menu to work with. Classic Shell also comes with a Classic Explorer component, for those who prefer Windows Explorer as it once was.

Unhappy with Settings? The Control Panel is still available, but it's not as easily accessible as it once was. Place it front and center by typing "control panel" into the Search bar, then right-clicking it, and choosing either "Pin to Start" or "Pin to Taskbar."

And speaking of the Control Panel, if you don't like the new Settings Personalization dialog, create a shortcut to the classic Control Panel way of doing things: Right-click inside a folder or on the desktop, and choose "New → Shortcut," then point it to "control.exe desk.cpl,Settings,@Settings." Job done!



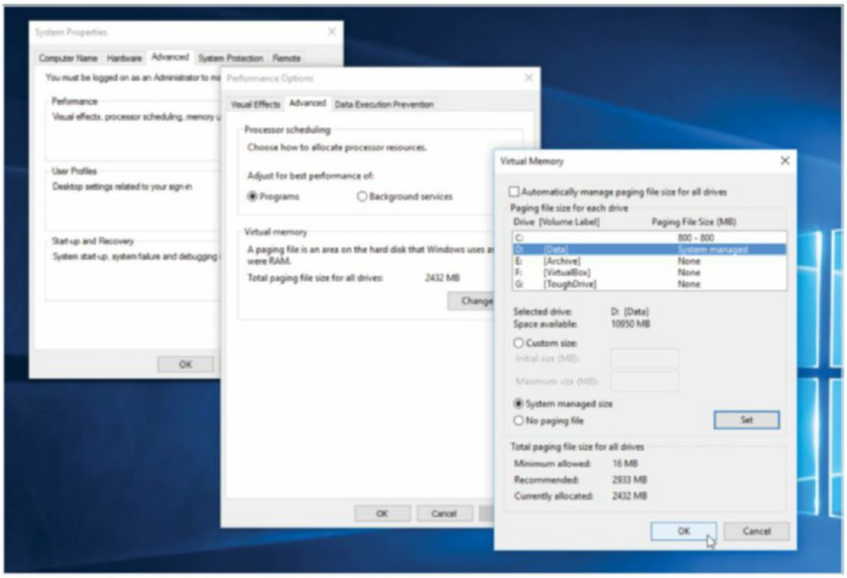
one to zero (only the first 10 are registered in this way).

Also look at customizing the Start menu and Quick Access menu (the one that appears when you right-click the Start button, or press Win-X). See "Start → Settings → Personalization → Start" for the former, and download the portable Win+X Menu Editor tool from http://winaero.com/download.php?view.21 to choose exactly which shortcuts to place on the latter.

If your PC is in a secure location and you are its only user, you can save a bit of time when starting Windows by bypassing the lock and logon screens. Type "netplwiz" into the Search box, and click the entry to access the hidden User Accounts Control Panel. Verify your account is selected, then untick "Users must enter a username and password to use this computer." Click "Apply," enter your user password when prompted, and click "OK" twice. When you next reboot, there's no password prompt.

Partition your hard drive

Does your data reside on the same drive as Windows and your programs? That's potentially bad news if Windows suddenly stops working and you're forced to reinstall from scratch. If you keep your data on a separate drive, problems with Windows and programs won't affect it, allowing you the security of troubleshooting and even reinstalling from scratch, or recovering a drive image without touching any of your precious files.


Virtual Memory

☐ Automatically manage paging file size for all drives

Paging file size for each drive

Drive [Volume Label]		Paging File Size (MB)
C:		800 - 800
D:	[Data]	System managed
E:	[Archive]	None
F:	[VirtualBox]	None
G:	[ToughDrive]	None

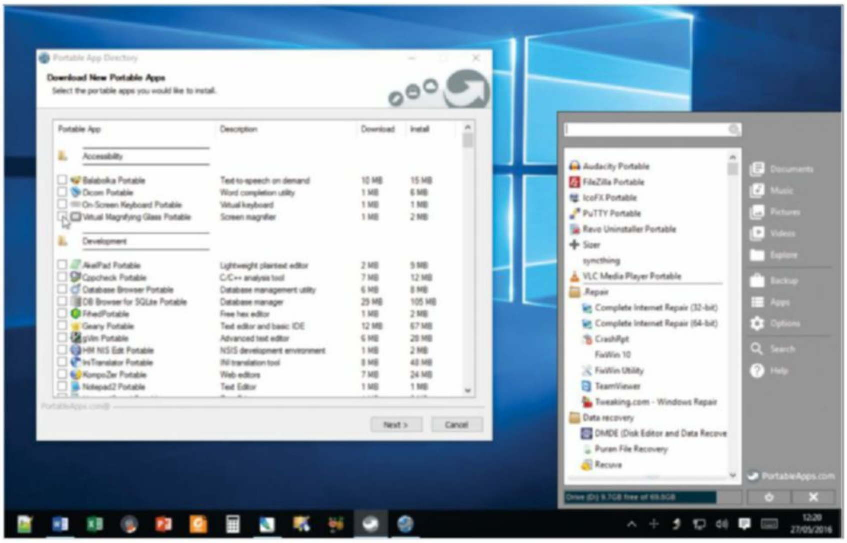
Selected drive: D: [Data]
Space available: 10950 MB

○ Custom size:
Initial size (MB):
Maximum size (MB):
● System managed size
○ No paging file

Total paging file size for all drives
Minimum allowed: 16 MB
Recommended: 2933 MB
Currently allocated: 2432 MB

Tweak virtual memory settings for better responsiveness.

Ideally, your data will reside on a physically separate drive from Windows itself, but this isn't always practical. Instead, investigate partitioning your hard drive, so you create two or more virtual drives in the space usually reserved for one. The tools you need can be found in Windows itself, but make sure you have enough free space on the drive to create a partition large enough to fit all your data files in. To get an idea of how much space you'll need, browse to C:\Users, right-click your username, and choose "Properties."



Portable apps can survive a Windows reinstall.

Now click "Start," followed by the "→" button next to File Explorer. Choose "More → Manage" to open the Computer Management Console. Select "Disk Management" under "Storage" to see a graphical view of your hard drive. Adjust the view at the top to reveal how much free space is left on the drive. If there's enough, you can proceed to the next step; if not, you'll need to temporarily move your data from your user folder to another drive, then—once you've verified it's safely transferred—delete the contents of your user folders (but not the parent folders, such as Documents or Pictures) on drive C to free up space.

Next, right-click drive C in the list, and choose "Shrink Volume." You'll see how much space is available to free up—if it doesn't tally with your findings, you'll need to employ a third-party partitioning tool instead; try Minitool Partition Wizard (www.partitionwizard.com), for instance. If there is space, leave at least 10GB (roughly 10,000MB) free, and click "Shrink." Once done, you'll see empty space resides next to your system partition. Right-click this, and choose "New Simple Volume." Follow the prompts to set up a full-sized partition, formatted using NTFS.

Once complete, you'll have a new drive to transfer your files to. To do this properly, so Windows knows where to find your user folders going forward, browse to "C:\Users\<Username>," then right-click each key folder—Documents, Downloads, Videos, and so on—in turn, choose the "Properties → Location" tab, then click "Move." Browse to a suitable location on your newly created

partition (create a folder if necessary), and click "Select Folder," choosing "Yes" when prompted to move your data across. If your data has already been moved to the drive, simply move it into the corresponding folders you've just created, and the job is done.

Build a portable toolkit

We love portable apps here at *Maximum PC.* They're confined to a single folder, don't clutter up your system, and—by storing them on your newly created data partition—survive a Windows reinstall, saving you the bother of reinstalling and setting them up again. Store that folder in the cloud or on a USB flash drive, and you can use them on all your machines, too.

An increasing number of programs—mainly system tools, like some of those we've featured, but also full-blown apps, such as LibreOffice, and even your web browser—now come in portable format. If this appeals to you, we recommend going to www.portableapps.com, where you'll find a handy platform that provides you with its own pop-up menu of easily manageable shortcuts, as well as update notifications for apps you install through the platform itself. And you can create your own shortcuts, too, enabling you to place them on your Taskbar or Start menu, for even easier access.

Hardware tweaks

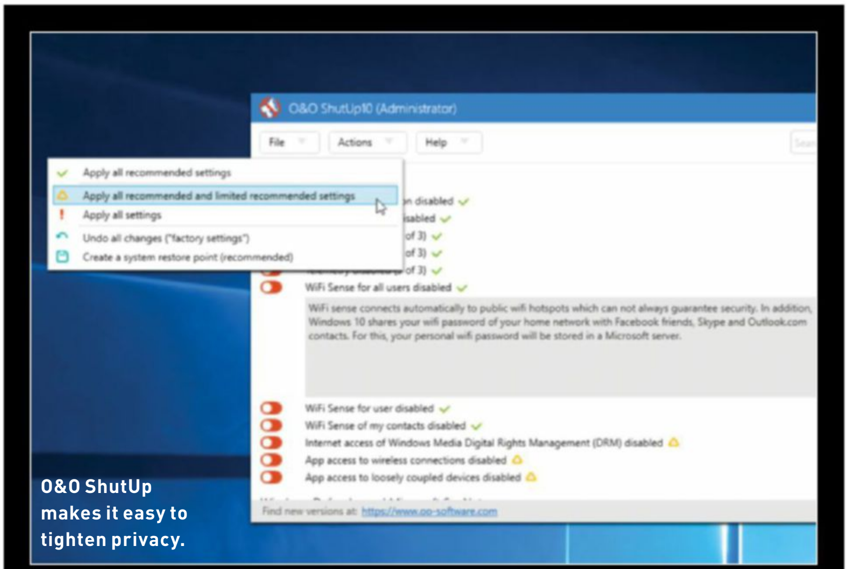
If you really want to lick Windows into shape, it's time to consider replacing that tired mechanical hard drive with a super-fast SSD drive. In fact, if you're upgrading your desktop, purchase a smaller SSD (say 128GB or 256GB) purely for Windows and your programs, then leave your data alone on your existing drive, keeping both physically separate.

Once your drive is fitted, and you're enjoying the sensation of Windows and programs loading in a fraction of the time they used to, why not check to make sure your drive is performing at its very best? Press Win-X, select "Device Manager" from the menu to open Device Manager, then expand "IDE ATA/ATAPI controllers," and verify your system has an AHCI controller instead. Now expand "Disk Drives," and double-click your SSD drive entry. Switch to the "Policies" tab to also verify that write caching is enabled (leave the "Write-cache buffer flushing" setting unticked).

With the basics checked, type "defragment" into the Search bar, and select "Defragment and Optimize your drives." Verify your drive has been correctly identified as a "Solid state drive," so it's optimized correctly (defragging SSDs is a very bad idea).

Next, visit your drive manufacturer's website, and see whether there are any drive utilities that exist that can tweak performance further—people with lots of RAM and Samsung drives should install Samsung Magician, for example, because it offers a RAPID Mode setting, which could speed up read/write times by utilizing spare RAM, although most people have reported that it has most effect on older, slower SATA-II interfaces.

You can speed up the performance of other drives, too—particularly USB ones. Return to Device Manager, and investigate the drive's Policies tab. Here you'll see the drive is optimized for quick removal, but


O&O ShutUp10 (Administrator)
File
Actions
Help
Apply all recommended settings
Apply all recommended and limited recommended settings
Apply all settings
Undo all changes ("factory settings")
Create a system restore point (recommended)

WiFi Sense for all users disabled ✓

WiFi sense connects automatically to public wifi hotspots which can not always guarantee security. In addition, Windows 10 shares your wifi password of your home network with Facebook friends, Skype and Outlook.com contacts. For this, your personal wifi password will be stored in a Microsoft server.

WiFi Sense for user disabled ✓
WiFi Sense of my contacts disabled ✓
Internet access of Windows Media Digital Rights Management (DRM) disabled △
App access to wireless connections disabled △
App access to loosely coupled devices disabled △

Find new versions at: https://www.oo-software.com

O&O ShutUp makes it easy to tighten privacy.

Deal with Privacy Issues

Windows 10 does not have a great reputation for respecting or protecting your privacy. While it's not quite the colander some would have you believe, the operating system definitely needs tightening up. So what can you do about it? If you're about to install or upgrade to Windows 10, make sure you don't choose "Express settings" during setup—you can then review exactly how Windows wants to track your behavior, and decide whether or not to allow it.

It's never too late to tighten privacy, even if you missed this step. Start by going to "Start → Settings → Privacy," and work through the available options. You can configure options such as which apps have access to your camera on an app-by-app basis, or choose a universal setting. If you don't like Cortana, be sure to select "Speech, inking & typing," and click "Stop getting to know me."

Once done, return to the main Settings screen. If you have Wi-Fi, select "Network & Internet → WiFi → Manage WiFi settings." Disable both "Connect to suggested open hotspots" and "Connect to networks shared by my contacts" to disable Microsoft's ill-conceived WiFi Sense feature, which will be dropped from the Anniversary Edition.

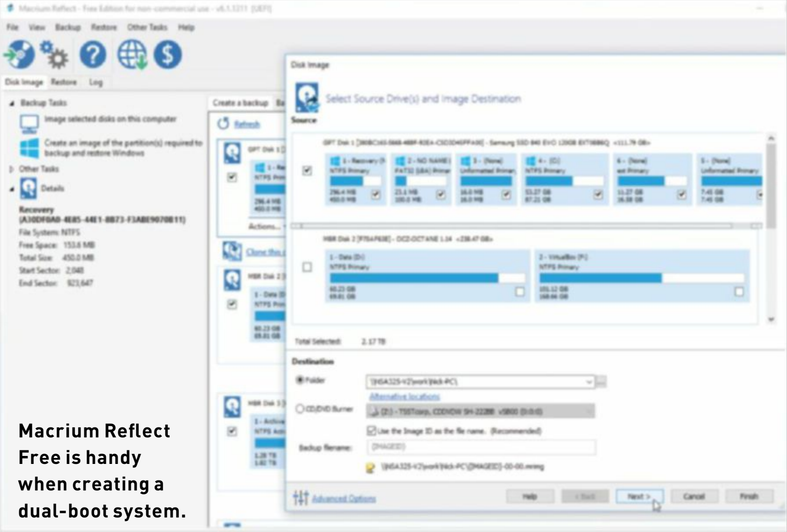
If all of this is too much effort, or you want help choosing appropriate privacy settings, you should download and run the free (and portable) O&O ShutUp10 tool from www.oo-software.com (look under "Downloads"). It provides a convenient list of all the most common privacy settings, which you can work through as a series of individual switches. Click a setting to get more information about it. Handy symbols indicate which ones are recommended for disabling (green tick and—with additional review—yellow triangle), and clicking the "Actions" button provides some neat shortcuts to applying all the recommended settings in one go.

if you rarely disconnect it, select "Better performance," having read the warning.

If you have two or more physical drives installed, consider moving your paging file to the non-system drive, to help speed things up—note, if your system drive is SSD, but the other isn't, skip this step. Open "System" via the Quick Access menu, and click "Advanced system settings." Click "Settings" under "Performance," switch to the Advanced tab, and click "Change." Untick the automatic option before selecting drive C. Choose "No paging file," and click "Set," ignoring the warning about Windows not being able to record information in the event of a crash (it'll be stored in the paging file on your other drive). Select your other drive, choose "System managed size," and click "Set" again. Click "OK" three times, and reboot when prompted. Once complete, return to this screen, and verify that drive C has no paging file, and your second drive has a system-managed paging file in place. With the load spread more evenly, you should see further performance improvements.

Is your PC as energy efficient as it could be? Get detailed information about your hardware's energy capabilities—plus any known problems—by generating an energy report from an Administrative Command Prompt. Type "cd %userprofile%/desktop" followed by "powercfg -energy." After about 60 seconds, an energy-report.html file is generated on your desktop—double-click it to review its findings in your browser. Visit http://support.microsoft.com/kb/976034 for more information about how to analyze its readings. From here, you can tweak your settings accordingly—both through the Power Options Control Panel, as well as Device Manager (look for a Power Management tab for available options).

Finally, want to clear out Device Manager? When you disconnect devices, they disappear from view, but if you select "View → Show Hidden Devices," they appear in the list. From here, you can right-click the device in question, and choose "Uninstall" to remove its drivers. ⏻


Macrium Reflect - Free Edition for non-commercial use
File View Backup Restore Other Tasks Help
Disk Image Restore Log
Backup Tasks
Image selected disks on this computer
Create an image of the partition(s) required to backup and restore Windows
Other Tasks
Details
Create a backup
Refresh
Disk Image
Select Source Drive(s) and Image Destination
Source
Total Selected: 2.17 TB
Destination
Folder
CD/DVD Burner
Alternative locations
Use the Image ID as the file name. (Recommended)
Backup filename:
Advanced Options
Help
< Back
Next >
Cancel
Finish

Macrium Reflect Free is handy when creating a dual-boot system.

Dual-Boot Windows 7 and 10

You've decided to put it off no longer, and are ready to upgrade to Windows 10 before the free offer runs out. But how can you both upgrade and keep your existing Windows 7 or 8.1 setup? This tip is for more seasoned users only. First, follow our advice to clean up your PC, and make sure Windows is fully up to date. Then follow our recommendations to hive off your data from your Windows partition, and shrink it further to leave space for another partition that will contain Windows 10—this needs to be the same size as your original Windows partition. Remember, if Windows' own partitioning tools complain about the placement of certain files on your disk, use Minitool Partition Wizard instead, which isn't as fussy.

Next, download and install Macrium Reflect Free (www.macrium.com/reflectfree.aspx), and use it to image your Windows partition to your backup drive. Also, make sure you create the rescue media—visit www.techradar.com/1319885 for a complete guide to using Macrium.

Now boot back into Windows 7 and upgrade to Windows 10, fully updating it when done, and performing a "clean" install only after the initial upgrade and activation if you require it. Now use Macrium to restore the OS partition (not the entire disk) to the blank space on the drive. This action means your main partition will be pointing at Windows 10, and your old Windows 7 partition now resides in the empty space that you created previously.

Reboot your PC if necessary, and then download and install EasyBCD from https://neosmart.net/EasyBCD/—you can then use this to add Windows 7 to the list of available boot options, giving you your dual-boot setup. If things go wrong, restore your Macrium drive image (this time, restore the entire disk instead of an individual partition), and start again.

Games
Windows 10

THE FUTURE OF VR

The problem with the future of VR isn't working out what it looks like, it's working out which possible future we might get

By Dan Griliopoulos

We've had a century and a half of imagining what virtual reality might be. The first pseudo-VR arrived in 1838, with Charles Wheatstone's stereoscope. This produced a 3D image using two splayed lenses and a pair of slightly different drawings (see "The First Headset," pg. 37).

Since then, we've been imagining what could come next. The first fiction to posit something recognizable as VR was Stanley G. Weinbaum's *Pygmalion's Spectacles,* in 1935. It featured a pair of goggles showing "a movie that gives one sight and sound... taste, smell, and touch... You are in the story, you speak to the shadows and they reply, and instead of being on a screen, the story is all about you, and you are in it."

After that, our concept of VR stabilized. We knew what it was going to be like, we just had to wait for technology to catch up. Palmer Luckey's creation of the duct-tape-and-prayer Oculus Rift prototype showed us the time had come.

Even now, there are multiple routes where VR may go. Is it going to be *Star Trek's* Holodeck, where VR is headset-free? A totally immersive all-body VR, like *The Matrix?* The parochial virtual universes of Iain Banks's books *Feersum Enjinn* and *Surface Detail?* Are we going to be masters of our own universes, as in *Otherland* and *Ready Player One,* or pawns, as in *Neuromancer* and *Snow Crash?* Let's consider the possibilities....

SAMSUNG
Gear VR
oculus

From a low budget to a high one, there's a VR headset for everyone.

THE SHORT TERM

At the moment, there are four major options for VR, in decreasing order of impressiveness and price: Valve and HTC's Vive; Facebook's Oculus Rift (we scored the Vive an 8, and the Rift a 7, to remind you); Oculus and Samsung's Gear VR; and Google's Cardboard. How are they each likely to improve over the next year or two?

As of this E3, the two big ones don't seem likely to change very much. The HTC Vive launched pretty much as a complete product, tied into the relatively mature Steam VR operating system, with a wide range of games available. Using it, the only thing it really needs is a fix for the blasted "screen-door" effect, and more powerful graphics cards.

As Epic's Nick Whiting says, "VR represents one of the most demanding computational applications, due to the resolution and framerate requirements. In the game development community, we were still looking at making games that can run consistently at 1080p at 60fps, and then VR upped the bar to nearly 2.5K resolution at 90fps. Add on top of that the fact that we have to render stereoscopically, and the result is that we've had to look back at older techniques, that we used to use in game development, to achieve the effects that we want at the speed we need."

Oculus Rift, on the other hand, launched too early to stay competitive within the Vive's launch window. Though a reasonable software lineup was in place, the core Oculus Touch controllers aren't due to launch until later in 2016, alongside an array of exclusive games. The CEO of Ndreams, Patrick O'Luanaigh, sums it up neatly: "VR is a 5–10-year thing, and we're in Year One."

As O'Luanaigh hints, for both platforms, the games aren't quite AAA yet. Most games coast on the immersiveness of the tech. The few good experiences—*The Climb, The Lab, Chronos,* and *Eve: Valkyrie*—are single mechanic ideas scaled up into full products; they all feel simultaneously a little small and overstretched, no matter how compelling and impressive the core loop.

Whiting thinks this is down to developers slowly getting to grips with the tropes of the tech. "With the rapid pace of progress on the technical side, I think it's easy to forget how long it takes to develop the rules for interacting with a new medium; the grammar and conventions. If you look back at early film, it took decades for cinematic conventions to take hold, and they're still evolving. I think we're seeing that same thing right now in VR, albeit at a much faster pace."

What might change that is the entry of the larger publishers into the field, who'll want to be on every platform. Ubisoft already has an *Assassin's Creed* spin-off app that it's demoing, and PSVR is being headed up by an array of familiar faces. As Whiting says, "I think a lot of the traditional funding vehicles, like publishers, were hesitant to start spinning up content teams to create experiences, because they didn't have a firm launch date or price point to try to determine if it was worth the investment. However, now that we're starting to see commercial headsets ship, that's changed." The addition of cheaper, third-party headsets, such as Razer's $400 HDK 2.0, will hopefully increase the market size, too.

THE CONSOLES

This year's E3 was a bit of a game-changer for console VR, with both Microsoft and Sony announcing new consoles designed especially to support VR and 4K (although, realistically, few gamers target 4K, even on PCs—95 percent of gamers play on 1080p or lower, according to the Steam Survey).

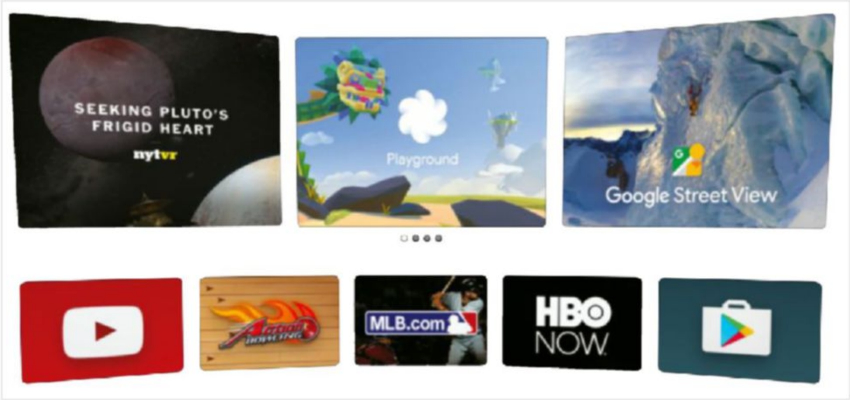
The first outing for a console VR system is likely to be the PlayStation VR. That's a pity, because it's the weakest of all the non-mobile VR systems we've encountered. From our time using the headset, it seemed ergonomically very slick, but the demos didn't throw lots of polygons around. And there were multiple reports from E3 of journalists experiencing "simulator sickness" on some of the new PSVR games.

So, both firms have recognized the need for better hardware. Sony's more powerful PlayStation Neo (aka the PS4.5) will use exactly the same PSVR as the PlayStation 4. Indeed, reports indicate that Sony is contracting developers to ensure that there are no feature differences for games developed for the systems—and no games exclusive to the Neo—so that it doesn't lose its existing user base.

Microsoft seems less protective of the Xbox One, presumably due to its weaker market position, but is still positioning its VR console Project Scorpio as an Xbox One Point Five. It's got slightly more power than the Neo—which it'll need to run the Oculus Rift headset that's widely mooted to be its companion—but still not enough to beat the current best of PC tech, such as the GeForce 1080.

Meanwhile, Nintendo of America's president, Reggie Fils-Aimé, said Nintendo wasn't getting involved in this fight. "We've been looking at the VR space since the days of the Virtual Boy. With us, we want to make sure that our next content is going to be mainstream, mass market approachable,

But be warned: experiences may vary!



The eternally improving Google Daydream virtual reality interface.

and when VR is at that point, you can expect Nintendo to be there." But not right now.

Despite those problems, Whiting and O'Luanaigh are among many who think that console VR has an advantage over PC. The huge install base for the consoles, and the lower price of PSVR compared to the big two on PC, will attract mass market customers.

Whiting thinks there are more subtle advantages to console, too. "You're working with a fixed platform, which takes a lot of the effort of making a VR experience scalable across different hardware configurations out of the equation. Additionally, Sony requires certification for all of its titles, and that helps ensure a quality experience. That's important, because unlike most traditional games, a bad VR experience can make you physically ill!"

O'Luanaigh agrees; "There will be over 40 million PS4s out there by the end of this year, and PlayStation VR is a high-quality, well-priced, plug and play platform that has already had massive levels of pre-orders. I expect Sony to hit VR hard."

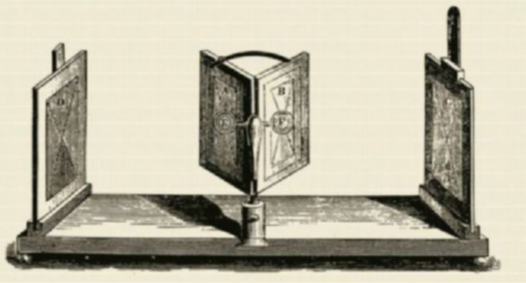
THE MEDIUM TERM

More mass market even than consoles is VR on mobile phones. Mobile VR has been mildly popular so far, but O'Luanaigh thinks it'll become truly mass market in the next five years. "I think you will see big improvements to mobile VR soon—in terms of power, comfort/size, control systems, positional tracking, managing heat (so you can play for long session lengths), and so on."

In particular, Google Cardboard has been a massive, successful experiment. By January this year, Google had shipped over five million Cardboard viewers, with over 25 million app downloads. That's a huge number, when estimates of Samsung's (much more expensive) Gear VR shipments are around the 800,000 mark. Google has also been working with HTC on the Vive, shipping the unique 3D oil painting application Tiltbrush for its launch.

Google Daydream is Google's next step in VR, and its bet is still on mobile VR. Daydream and the VR tools to run it will be built into the next version of Google's mobile OS, Android N, and developers are already building software for it. Much like the Gear VR, Daydream is a relatively premium product, built for high-quality, extended use. It comes with a unique controller that's a bit like a very small Wiimote—its rotation and orientation are accurately tracked, and it has a small clickable touchpad.

Whiting thinks this is crucial. "A big step in the right direction for bringing more serious entertainment content to the mobile platforms is adding a standardized



THE FIRST VR HEADSET

And the birth of 3D, all in one!

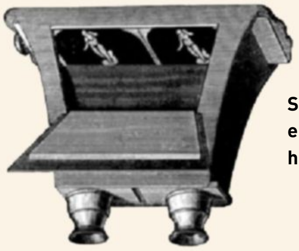
To us, using it today, virtual reality seems a unified idea, a combination of aural, visual, and vestibular (balance) stimuli, which gives a convincing sensation of being in a false location. By contrast, the very first thing that looks like VR was the Brewster Stereoscope, based on Charles Wheatstone's Stereoscope.

Wheatstone was one of those 19th century inventors who seems to have been involved in every invention of his era—electronics, cryptography, telegraphy, spectroscopy, acoustics, and so on. To make the Stereoscope, he had to explain binocular vision first, and how it gives the impression of solidity to the world (crucial in VR).

Wheatstone's Stereoscope was less impressive, but established the basic principles of virtual reality. It used different images for each eye, reflected by an individual mirror. However, this happened in 1838, the year before the photograph was invented, so the images were hand-drawn, and could be made very large if required.

Much like modern virtual reality, each image was slightly different, simulating the different views of an object from the left and right eyes. The brain fused the image in the same way, resulting in what appeared to be a 3D object with depth of field.

Brewster's later lenticular Stereoscope, which looks much like a View-Master, used lenses rather than mirrors for presenting the different images to each eye, and was on a much smaller scale.



Steampunk, eat your heart out!

OSVR
SAMSUNG

As impressive as VR is, we still need consoles to the lead the way for developer investment.

controller. Without a controller, you're very limited in the interactions you can perform in a game. I think that's why you see so many turret shooter-style games on mobile currently."

That said, mobile VR still has bigger problems to overcome, both in software and hardware. "While PC VR is hard, in a lot of ways, mobile VR is even harder!" says Whiting. "You're on a much more constrained platform in terms of performance, and you also have to contend with heat and battery life issues. All that means that you either have to greatly simplify your content, or you have to really put in a lot of effort to making things look great."

THE OTHER CREATIVES

Beyond the hardware, the experiences that are being created will change substantially in the medium term. Because, although the first wave of VR kit was bought by developers (mainly indie developers) through Kickstarter, it's been widely disseminated throughout the games industry. With the backing (and money) of Facebook and HTC, Oculus and Valve have given away thousands upon thousands of developer kits to developers. And HTC has just launched a new $100 million investment fund called Vive X, to "cultivate, foster, and grow" the global VR ecosystem.

Yet they're already making other moves. Because all that funding and drive isn't just going toward game developers—the other creative industries are circling, and keen to get involved. This could be an excellent outlet for movie creators, desperate to break out of the big cinema, big production cost loop. One could argue that the natural place for Guillermo Del Toro and Terry Gilliam's feverish creations is in a first-person virtual nightmare.

Some directors are already making the jump. For example, blockbuster film director Michael Bay (*Transformers, Pearl Harbor, Bad Boys II*) announced in June 2016 that he was working with a new Hollywood studio, The Rogue Initiative, to launch a "gritty, danger-close action, coupled with (his) signature style and storytelling." The Rogue Initiative also brings together management from Activision, Disney, and Pixar, and is currently working up at least four movie-style projects for VR. And Oculus has already snapped up some ex-Pixar folk to make *Henry,* a VR animated short, as well as larger projects.

Whiting sees the trend going further. "Film, architecture, and design have all gone in head-first. However, many of those fields don't have a lot of experience in real-time rendering, which presents a significant challenge. That means we have to find ways to make it easier to technically create visuals at the fidelity they're looking for, without necessarily having them fundamentally alter the way they make content. I think this is why you see so much excitement over techniques like multi-resolution rendering and hardware-accelerated stereoscopic rendering. The more efficient we can make the rendering for VR, the easier it will be to create great content."

SOCIALIZATION

The most important element that's missing from current VR systems is also one that the Oculus Rift is perfectly placed to solve: social networks. After all, since 2014, Oculus's owner has been Facebook, which seemingly bought it to shore up the possibility of its social network being undermined by future technology advances, in the way MySpace, Friendster, and Bebo were destroyed.

Already, independent developers are releasing social VR apps, hoping to get the early starter advantage on the big companies. Altspace VR is one such app, that enables users to meet up in chat rooms, and play games with other users. Ruairi Rodinson, a QA consultant and game developer, has been meeting people in it.

"It was very different," says Rodinson. "I've played many MMOs and LAN games over the years, but the simple fact I was making eye contact, and watching people's heads and hands for body language, meant

THE SIMULATION HYPOTHESIS

Is life just a game where we make up the rules?

"There's a one in billions chance we're in base reality," said Elon Musk, the billionaire inventor behind the Tesla car and SpaceX rockets, and founder of PayPal. Talking at the Recode Code conference, he said he thinks we're almost certainly computer-generated creations of a more advanced civilization's simulation—a video game.

Musk pointed to the advances in video games technology over 40 years, from *Pong* to "photorealistic, 3D simulations with millions of people playing simultaneously... virtual reality, augmented reality." He pointed out that we're "on a trajectory to have games that are indistinguishable from reality, and those games could be played on any set-top box, or on a PC, or whatever, and there would probably be billions of such computers or set-top boxes, so it would seem to follow that the odds we're in base reality is one in billions."

This thesis was first created by philosopher Nick Bostrom, and is a combination of concepts from two 17th century French philosophers. The first is René Descartes, and his concept of the Evil Demon *(malin genie).* This is the possibility that we're being deceived about the world around us by an all-powerful creator—in this case, a video game programmer.

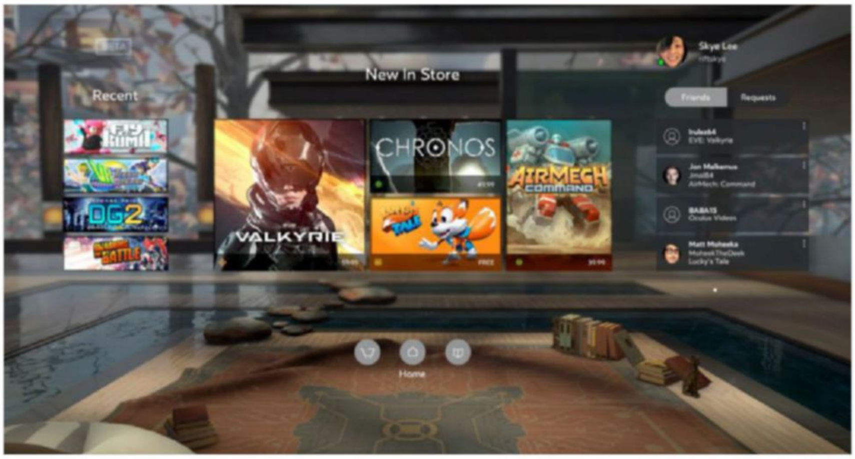
Then Blaise Pascal's Wager says that, however small the probability is that God exists, the huge threat of being wrong, missing out on heaven and landing in hell, means it's rational to believe in God. Musk turns that into a tiny probability that computers could replicate reality, and a huge amount of time.

Bostrom is less certain. He thinks it's impossible to determine whether human-level civilizations will reach the point where we can and want to run convincing simulations. We don't have any way of knowing whether such civilizations ever get to run these simulations —or whether they want to, if they can. Not that a simulated individual would know.

Nick Whiting is more impressed by the implications of the theory. "The fact that the theory even exists is a testament to our desire as humans to be able to create and play with reality. We've always sought to bend the rules, and harness them for our own progress. That's the ambition that drives scientific discovery, and I think is part of why so many people see so much potential in VR. VR is a world that we can create and manipulate as we see fit, and there's a lot of fun in that!"

CREDIT: STEVE JURVETSON

The Oculus Rift and HTC Vive went head to head last issue, with the Vive coming out on top.



The Oculus home front in all its three-dimensional, VR glory.

it felt like I was in a room with people. Heck, the fact I could just walk away from the table and talk to someone in the corner, without exiting anything or losing the flow, similar to hanging out in a bar, made it unique—more like a pub experience, if you were meeting folk for the first time."

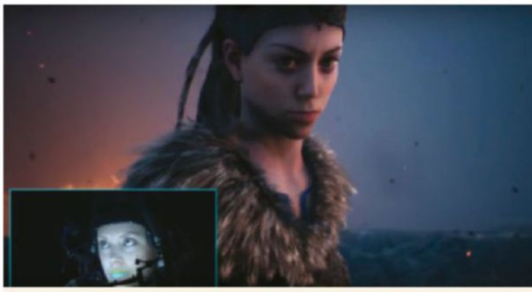
That said, there were social elements that still needed technical fixes. Because Altspace is available on multiple devices, players have a greater or lesser capability to interact. "Some people got in your space," says Rodinson. "They just stood too close. It felt rude, from strangers. Some got it, whilst others, who I'm thinking were playing on Gear VRs and flatscreens, didn't 'get' the personal area, because folk with 'hands' *[indicating a pair of Vive controllers]* tended to give a bit of space to me. But, still, I kinda wished for a 'bubble' to push people out of a space that I could define unless I wanted them in it."

THE LONG TERM

The long-term future of VR could go any direction. O'Luanaigh thinks there are still huge technical advances to be made, which will require new great leaps forward in other technologies. "VR display technology that doesn't use screens in front of your eyes—something like virtual retina displays that beam photons into your eye, meaning very small headsets that look like a pair of glasses (possibly just a small frame). This will allow AR and VR to work together, and for users to switch between one and the other. I'd love to see positional tracking that doesn't require external cameras or markers. I'd love to see untethered high-end VR headsets. And I'd love to find a great solution to walking/running on the spot in VR."

We referred to *The Matrix* and *Star Trek* earlier. It's notable that many of these depictions of VR have been, in part or wholly, negative. The Holodeck was always threatening to escape its bounds, *The Matrix* was about the enslavement of mankind in VR to power AIs, and cyberpunk novels such as *Neuromancer* were about society's breakdown with the advent of VR.

That probably says more about the apocalyptic imperatives facing science fiction creators if they want their novel to be successful, than it does about the possibilities of the technology. But it's true that, because of its immersiveness, VR is something that can be used for good—psychology, doctors, social networks—and bad: torture, propaganda, and brainwashing. The only limit is the human imagination—and you might say that's no limit at all. ⏻



BRIDGING THE UNCANNY VALLEY

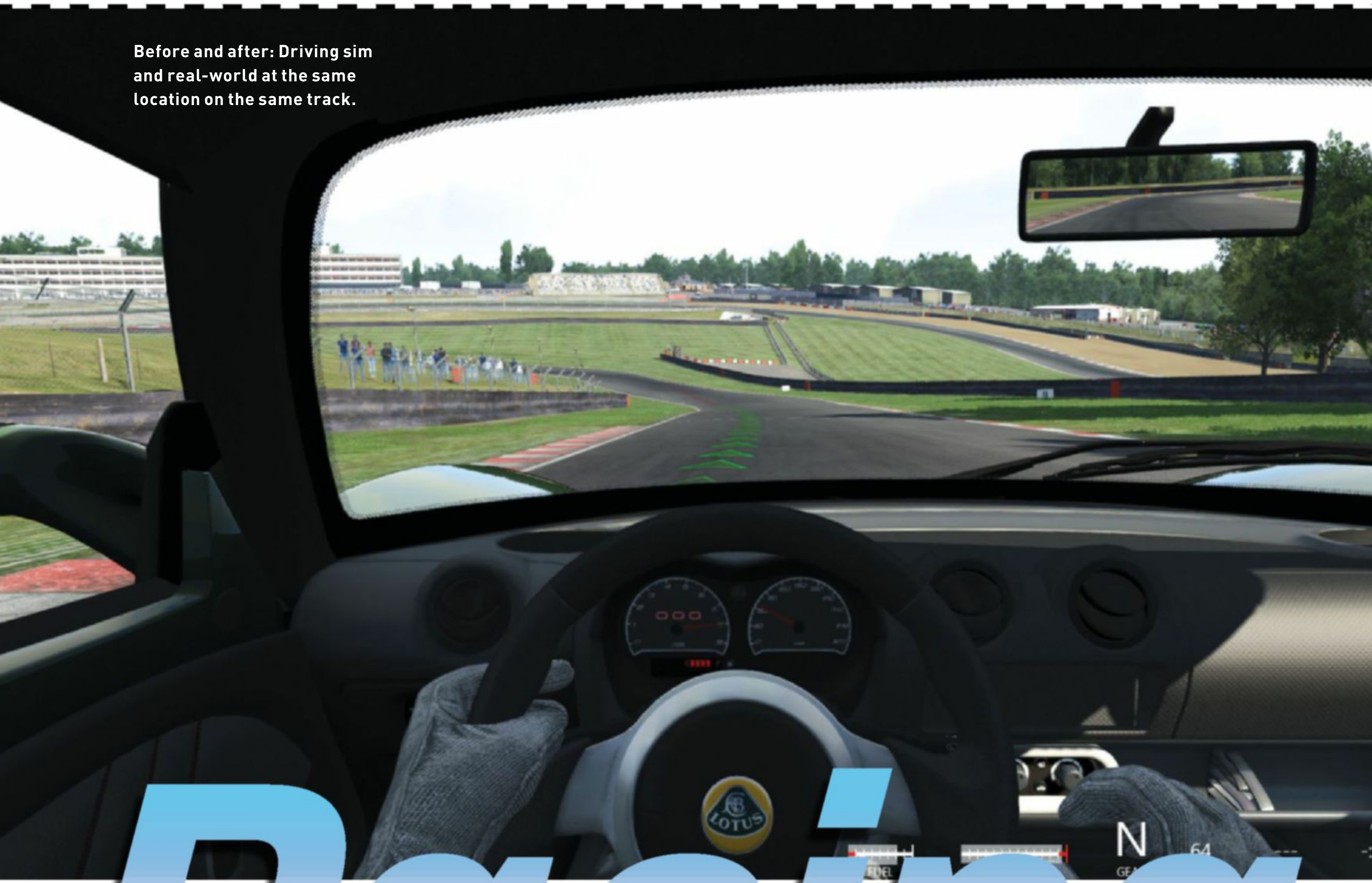
Merging motion picture with video games

One of the biggest problems for VR is overcoming the uncanny valley—the point where human actors need to be much better. *Unreal's* Nick Whiting has been specifically working on this: "The real magic of VR is in developing interactions with other characters. Because the user is actually a part of the world with VR, developing empathy with other characters is a much more powerful narrative tool than in other mediums if done right."

Whiting points to a technique in Neal Stephenson's novel, *The Diamond Age,* that's inspired him to create a solution. "One of the characters interacts with a techno-storybook that creates a narrative around her actual situation. It then outsources actors in a futuristic version of mo-cap suits, to act out the parts for the storybook's virtual characters. I thought this was a particularly neat idea, since humans are way better at acting human than computers! It skirts the uncanny valley by using real human movement and facial animation, instead of trying to fake it."

So at this year's Game Developer's Conference, Whiting's firm Epic collaborated with several games companies (Ninja Theory, 3Lateral, Cubic Motion, IKinema, and Xsens) to create a demo that used live motion capture data from an actor and fed it, in real time, into a high-quality cinematic.

"That was the turning point, where Neal's vision in *Diamond Age* finally seems attainable with virtual reality. If you look at the rig used, it's complicated, but all the components will eventually come down in price and complexity, and we can make those sorts of interactions practical for widespread use in VR. Many people dream of the so-called metaverse, but to me, before you can make that a highly compelling social experience, we're going to have to start taking these bits of hardware and technology that can capture the subtlety of human expression, and then broadcast it into a virtual world."



Before and after: Driving sim and real-world at the same location on the same track.

Racing

Can a real-world car lover truly enjoy driving sims? *Jeremy Laird* is about to find out...

PC games let you do awesome stuff. You know, stuff like riding a dragon, building a city, commanding a Roman legion, wailing on a zombie with a big stick, or braining an innocent bystander for the dumb thrill of it. In other words, stuff that's either very hard or actually impossible to achieve in real life. Well, that and stuff that's thoroughly inadvisable, such as braining people. But driving cars? You can drive cars in real life.

Personally, I drive a lot of cars in real life, thanks to being a car hack, as well as a technology journalist. So here's the thing: I've loved PC games for as long as I can remember. I've loved driving cars for as long as I can remember. But driving games? Not so

reality

much. Since I learned to drive, my default position on driving games has been the assumption that driving even the most mundane shopping car in real life is more engaging than getting behind the wheel of a virtual supercar car. Or racing car. Or whatever.

But maybe I've got it wrong. Maybe the latest driving sims, complete with hyper-accurate physics, and force-feedback peripherals, not to mention the latest display technology, add up to something a real-world car lover can dig after all.

To find out, we're going to need to do this right. That means the right hardware and the right games. Jabbing away at the keyboard while sitting at a desk isn't going to fly. I'll need some kind of uber display, a full-on driving seat, a wheel, a pedal box—the whole nine yards. Then there's the software side of the equation. Will chasing realism be the key to enjoyment? Or is that always going to be a doomed mission, and keeping it arcadey, simple, and fun is the way to go? Either way, the learning curve is going to be steep; mistakes will be made.

Overall, then, this promises to be quite a ride, a dive into the unknown but shot through with familiarity. There's a fair bit of baggage, bias, and baked-in preconceptions to drag around the track, too. Can a real-world car lover, even one who is a big fan of PC gaming, really love driving sims? Let's find out.

Doing this in your own car is crazy fun. Can a driving sim really compete?

First, a confession. Depending on how you look at all this, you could argue that I'm a poor candidate for this gaming experiment. The problem is that I'm particular—and I mean really particular—about cars.

I prefer them analog and involving. The latest sports cars with paddle-shift gearboxes, driving modes, turbo engines, driver aids, and power-assisted everything leave me cold. Give me a manual gearbox, minimal computer intervention, and a zingy naturally aspirated engine, please.

In that context, the odds of me gagging on an entirely synthesized driving sim seem pretty solid. But the genie is out of the bottle. I'm never going to forget my experiences in real cars, and that's also what makes this experiment intriguing. I'm not an expert in driving sims. But I've got a little form in both PC games generally and driving. So, can I really come round to the delights of driving sims?

The theory of games and why we play them enters the equation, too. Isn't gaming about escapism, doing things you can't normally do in real life, like the aforementioned dragon-riding?

Of course, I can't race in the Indy 500 in real life. But I can drive a real car on a real track. If I really wanted to, I could get up very early tomorrow morning, jump in my car, and make it in time for a few evening laps at the infamous Nürburgring in Germany. While it wouldn't be cheap, it wouldn't completely bankrupt me. So the baggage I bring to all this is that I struggle to compute the appeal of a virtual Indy car compared with any kind of real-world driving. But hold that thought—we'll be coming to the question of cost momentarily.

PROJECTOR PROJECT

The first hurdle to leap is the hardware setup. Having just completed a new projector-powered gaming dungeon in my basement, the display tech takes the form of a gaming-centric short-throw projector, courtesy of the Optoma GT1080, a 1080p DLP model. Now, you might think a projector would be one of the more expensive parts of this project. At $699, the Optoma ain't cheap, but nor is it the four-figure bank account buster you might fear.

Admittedly, there are compromises at this price. The GT1080 has low-spec optics that make achieving a perfect setup in terms of image size, geometry, and focus tricky. It doesn't even have zoom adjustment; you physically move the projector to change the size of the image. But its short-throw characteristics mean it can be situated in front of the rest of the rig, and still fill my nine-foot screen.

As for the gaming PC, the beauty of this kind of setup, and using a 1080p projector, is that the demands on your system are pretty low. Driving games aren't hugely demanding, and driving a mere 1920x1080 pixel grid is peanuts compared to a high-spec PC monitor weighing in at 2560x1440 pixels, or more. So my spare rig, running an elderly AMD Radeon HD 6970 and a two-year-old quad-core Intel Core i7, is plenty.

From here, it gets trickier. One of the big surprises for me has been the cost of driving peripherals. One of the main reasons to play a driving sim rather than really drive is cost. Driving any kind of car is expensive. Racing is one of the best ways ever conceived to make a small fortune, but the problem is that you

VIRTUALLY PERFECT

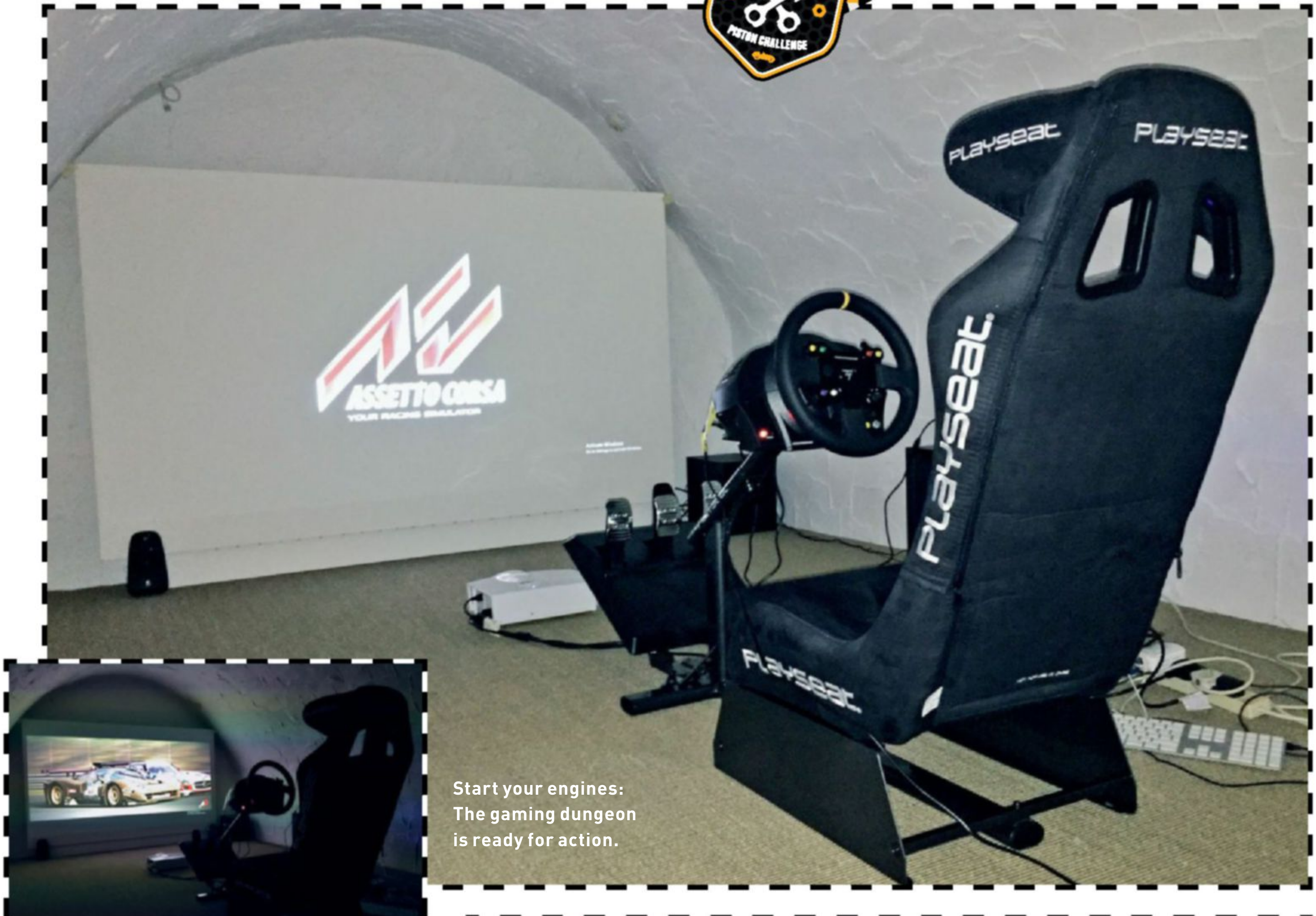
Are VR and driving sims a marriage made in gaming heaven?

There's a lot of debate over how suitable the new VR headset duo is for various types of gaming. But most agree the big problem involves moving around in the virtual game world. It's a major problem to simulate walking around a game world, even with a big space. You soon run into the limitations of the real world.

But driving games don't have that problem. You sit in the seat and that's it, just like the real world. Bodily, there's no need for you to move another inch. Perfect. What's more, a VR headset helps a lot with one of the trickiest bits in adjusting to a driving sim: depth perception and judging distances. Combined with minimal physical feedback, it can make things such as picking braking and turn-in points, along with generally positioning the car on the track, much harder in a sim than real driving.

If there is a problem with using a VR headset, it's not specific to driving games. It's that screen-door effect, due to the limited resolution that impacts all gaming. It's a problem that will almost definitely be solved with higher-resolution iterations of the HTC Vive and Oculus Rift in future. For now, it's something you just have to adjust to. Of course, it's also worth remembering that VR headsets are very demanding when it comes to rendering power. You're pumping more pixels at a higher frame rate than when using a 1080p projector at 60Hz refresh, that's for sure.

A VR headset is probably the best overall display solution for fully immersing you in the driving sim experience. But we found that a short-throw projector was a remarkably effective second-choice setup. The caveat to that is that you'll have to put a little work into getting the field-of-view settings right to give you the most realistic view out of the car. Switching off the rendered steering wheel, and sticking with simply the view through the windscreen, makes sense, too.



Start your engines: The gaming dungeon is ready for action.

On board and kind of up to speed.

must start out with a very large fortune. Racing cars will wipe you out financially.

DRIVING PRICES UP

Now, I'm not saying that driving sims are on anything like that level. But it was still a double-take moment when I saw the price of the Thrustmaster TX wheel and pedal box combo. $468 for some gaming peripherals? And we're not even talking about high-end enthusiast equipment.

The final major piece of the puzzle was a driving seat. For that I turned to one of the bigger boys in this part of the market: Playseat. The Playseat Evolution Alcantara model pictured here rocks in at $369, and there are other, similar models available for around the same price. Admittedly, it has a few limitations, as you can read about on page 45, but it was still the one item that was a little more affordable than I was expecting, especially given how important it is to achieving an authentic feel.

With the projector aligned, the seat assembled, and the Thrustmaster bits installed, I was good to go. The only question was what to play? The options were realism with a high-end sim on the one hand, or simple thrills with something arcadey on the other. My hunch was that a full-on sim was more my thing. I also had an inkling that trying to get as close as I could to my own real-world experience would be an interesting way to get things rolling.

For better or worse, the game I chose was *Asseto Corsa*. Apart from reading good things about *Asseto Corsa's* driving dynamics, it offered a couple of crucial features. First, I could start on a track I've driven in the real world, namely the one-time Formula 1 race track that is Brands Hatch, just outside London in the UK. It also included several cars I've actually driven, including a second-generation supercharged Lotus Elise.

So this is how it all began. First, some tweakage in *Asseto Corsa's* settings. I didn't want to make things too easy; I wanted the full deep-end experience from the get-go. So, I turned off the stability and traction control systems. The result was shocking. On my very first lap out of the pits, braking

BUILD YOUR OWN DRIVING SIM

It's expensive, but worth it

So, you're interested in rigging up a driving sim. What are the bare minimum ingredients, and what's recommended for the best experience?

Perhaps contrary to what you might assume if you have no previous experience of driving sims, peripherals—rather than display technology—are the most critical components. We would recommend a proper seatpod, along with both a decent force-feedback wheel and a pedal box.

As we found, those items can quickly add up to serious money, especially if you want a pedal box with decent feel, thanks to load cell technology. You could easily spend $1,000 for your seat, wheel, and pedals. Scary.

We've touched on the VR display option on page 42, but if you're going with a more conventional screen, size is more important than resolution for driving sims. 1080p on a big display is plenty, which means a cheap HDTV can work well. Multiple monitors for an expanded field of view can be great, too, but obviously come with cost implications. The projector option we went for worked surprisingly well, but it can be tricky to set up, and it's less flexible. Even really bright projectors really only look good in low ambient light conditions.

As for your actual PC, if you're going down the 1080p display route, via some kind of flat panel or a projector, you won't need all that much graphics firepower. A mid-range GPU and CPU combo should be plenty. Go for a multi-monitor or VR solution, though, and you're going to need high-end graphics. But, then, your budget is probably going to be that much bigger, anyway.

Overall, getting into driving sims and achieving a decent experience isn't going to be cheap. There's no avoiding that. But if you already have a large display of some kind, you can get most of the fun for under $1,000.

There's a little DIY involved in the assembly, but the result looks seriously slick.

into what's known as the "Graham Hill" corner on the Brands Hatch Indy circuit, it felt like my guts were trying to exit my body through my feet. Genuinely, it was intense.

Very likely, it was the combination of the huge screen filling my field of view, the Playseat delivering a familiar seating position, the steering wheel tugging at my hands, and the noise filling the gaming dungeon. Whatever, my brain was fooled into thinking there was some real driving going on, so when I was braking into that downhill corner, it was confused, and began to generate some intense and completely phantom physical sensations. It was as though I had a hydraulic rig operating in my mind. Truly, it was weird.

The intensity calmed pretty quickly over the opening laps, which I might add were messy as hell. From there, I could begin to get to grips with the whole experience of driving sims, the things that were familiar, and the things that were completely alien.

One of the aspects that works best is the steering feel. The *Asseto Corsa* team has done a very nice job with that, and the Thrustmaster wheel really delivers, too. Overall, I was very impressed with how the essential character of the Lotus Elise's rack has been captured. It's not a perfect or complete rendering, but it's on a completely different level from what I was expecting, and it's surely a big part of what made for that intoxicating initial experience.

FOOT NOTES

At the other end of the scale is the pedal feel. Put simply, it's crappy. Nobody who has even the most cursory understanding of cars or driving signed those Thrustmaster pedals off. The biggest issue is the brake pedal, which is far too long in travel, and too soft and springy in action. It's horrible.

At this stage, a little research taught me that what I need is a pedal box with load cells, which allow brake modulation based on pedal pressure, rather than pedal movement. That can be achieved with certain pedal boxes via aftermarket modifications, though I can't comment on how easy or effective that is. Or you can snag a pedal box that comes complete with load cells from an outfit such as Fanatec, though that will add around $400 to your driving sim bill of materials.

Once I began to get to grips with the basics and the weirdness, what was really fascinating was that I found myself in much the same rhythm that I do during a track day in real life. Working on lines and braking points, feeling frustrated with my lack of talent, but pounding round and occasionally being rewarded by momentary exhilaration when I nailed a corner just right, or finally

If you can drive the Nürburgring in real life, does that make racing sims seem silly?

An unpromising jumble that quickly turned into a serious seating solution.

PRIMING THE PLAYSEAT

A good-quality seat is crucial

Doing driving sims right means acquiring a whole hill of new hardware. One of the most critical items is a driving seat. We can't overstate how important being in the right seating position is for mimicking that authentic behind-the-wheel feel. Bolting a wheel to your desk and plopping yourself into an office chair just ain't the same.

Enter the Playseat Evolution Alcantara. It's one of the more affordable seatpods in Playseat's range, at $369, but it's a full-feature job, with an adjustable bucket seat, and mounting plates for a wheel, pedal box, and gearshift. There are other similar models available for around the same price, or more.

Initial deboxing impressions involve an unpromising and slightly intimidating jumble of parts. But the instructions are clear, and assembly is much simpler than anticipated. Twenty minutes later, and you'll have a rather sexy looking seatpod.

Overall, there's plenty to like. The bucket seat is probably a little broad for my skinny frame, but the result is still the right kind of seating position to put you in the mood for driving. If there is a problem, it concerns the lower forward part of the steering wheel support. It clashes, ergonomically, with the pedal box platform, making it tricky to get both the pedal box and the wheel in ideal locations.

The oversized proportions of the Thrustmaster pedal box we've paired with the Playseat make matters worse. But the design of the wheel stand makes it likely you're going to run into at least some problems getting an ideal pedal position.

For that reason, our recommendation from the Playseat range would be one of the Revolution models. The Revolution has a tweaked steering wheel mount that solves ergonomic conflict with the pedal mount. It's otherwise very similar to the Evolution seatpods, and roughly the same price. Thus, it's a bit of a no-brainer. Head to www.playseatstore.com to browse the full Playseat range.

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understood where I was getting something wrong with my braking points or turn-in. It was a hell of a lot of fun.

But the really impressive bit, in terms of confirming how realistic the sim setup turned out to be, is that I was quickish in the same parts of the track, and was struggling to find the absolute best line in the same parts, as I am when driving the circuit in the real world. That, I think, is remarkable.

BRAKING POINT

On the other hand, there was plenty that was different about sim driving. Those pedals make judging braking points darn difficult. I found it a real challenge to judge entry speeds, too. But the biggest issue is the lack of feedback beyond the steering. Seat-of-the-pants feedback, what you might call your built-in G-sensor or butt dyno, is such a big part of driving a real car, and its absence in driving sims—at least, when you aren't running some kind of mega-money hydraulic rig—is the biggest limitation when it comes to realism. I often feel disconnected by modern cars in the real world, but that problem is far worse when it comes to driving sims.

I did also try the arcade-style option, courtesy of the new *Forza Motorsport* demo for PC, but almost instantly I knew that style of gaming isn't for me. Realism to the max, please. Overall, the whole experience left me with mixed emotions. In many ways, driving sims are massively more realistic and engaging than I dreamt possible. But when the initial euphoria cooled, I realized that a long-term driving sim habit would be a serious commitment.

Firstly, I'm sure that online competition is what I'd need to fill that hole left vacant by the limited physical feedback. But I also know from my *Counter-Strike* days that being even half competitive online is a hefty commitment. You need to be at it all the time just to keep up.

Then there's the temptation to tumble down the rabbit hole of super sims. I haven't put enough hours in to really run into the limitations of the Thrustmaster wheel, but that would almost certainly happen in time. Then I could see myself going through multiple upgrade cycles with both the wheel and the pedals, and maybe even the seatpod, too. It would be all too easy to spend thousands of dollars chasing the perfect super sim setup. That's a little scary, and also makes me ponder the point of it all. For a few hundred bucks, driving sims are good, clean fun. But if I have to spend thousands to keep my interest levels up, that's a whole different ball game. The harsh truth is that I'd prefer to spend those dollars on real-world driving. ⏻

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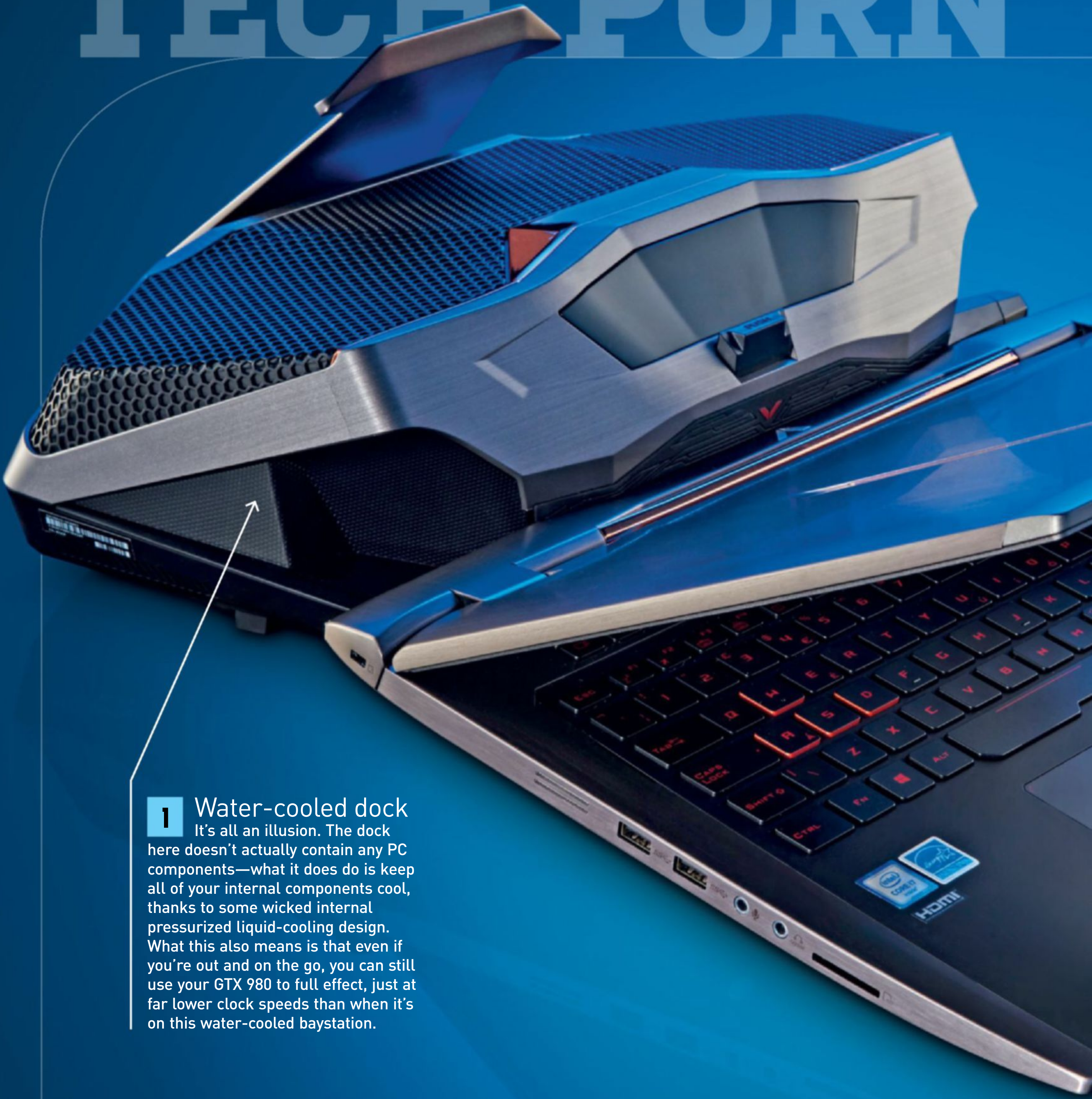

1 Water-cooled dock

It's all an illusion. The dock here doesn't actually contain any PC components—what it does do is keep all of your internal components cool, thanks to some wicked internal pressurized liquid-cooling design. What this also means is that even if you're out and on the go, you can still use your GTX 980 to full effect, just at far lower clock speeds than when it's on this water-cooled baystation.

2 Sleek screen

Is this the ultimate 1080p gaming laptop? Damn straight it is. Couple that GTX 980 with a full 17.2-inch IPS 60Hz 1080p screen, and you're looking at some joyous AAA 60fps gaming, no problem.

3 Intel Core i7 -6820HK

It's not all about the GPU, though. Inside here lies Intel's i7-6820HK. Packing four cores, eight threads, and capable of overclocking, you can bet your ass that this little beast will massacre the mobile competition. As good as a desktop? Not quite, but close enough.

READ THE REVIEW PG. 76

Asus ROG GX700

THERE'S SOMETHING marvelous about the insane. Something quintessentially American about taking a simple concept, and pushing it to the absolute limits of what it can do. Take the humble gaming laptop—for the longest time, mobile processors were the bane of any gamer's existence.

A GTX 860M, for instance, was no better than a stripped-down GTX 750. Yet the last few years have seen revolutionary improvements in smaller manufacturing processes, giving the likes of Skylake and Maxwell the chance to run under ever lower frequencies and temperatures. It wasn't long before Nvidia announced the fully mobile GTX 980, a graphics processor more than capable of running in gaming laptops.

So, that means an underclocked version, then? Well, for Asus, that simply wasn't good enough. Instead, it opted to make something radical. Welcome to the GX700, the world's first water-cooled gaming laptop. Comprising an external dock, which boasts a pair of 120mm radiators, this punchy monster can easily power any AAA title at 1080p without a sweat, and weirdly makes it perfect for a bit of overclocking, too. Couple that with the 8GB of VRAM, and you're looking at a GPU that can easily surpass its desktop counterpart, as far as 1440p and above is concerned. **–ZAK STOREY**

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72
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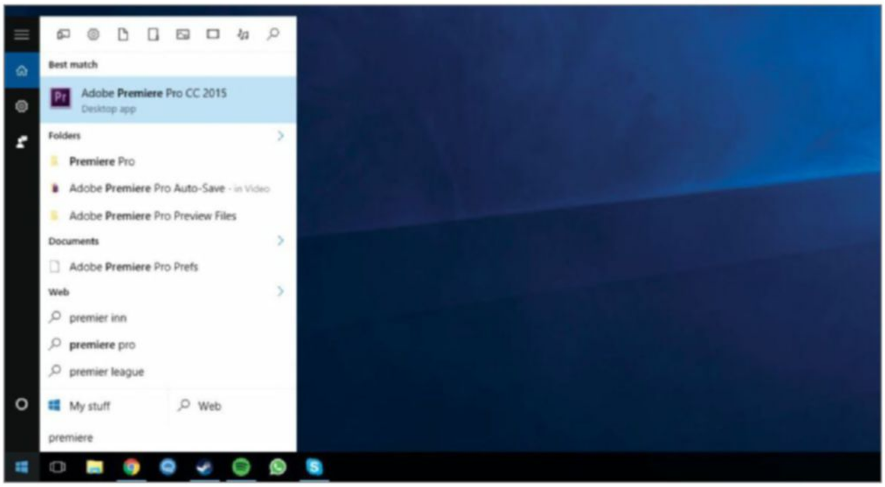
techradar.com

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH


Best match
Adobe Premiere Pro CC 2015
Desktop app
Folders
Premiere Pro
Adobe Premiere Pro Auto-Save - in Video
Adobe Premiere Pro Preview Files
Documents
Adobe Premiere Pro Prefs
Web
premier inn
premiere pro
premier league
My stuff
Web
premiere

SEARCH FOR PROGRAMS QUICKLY

It may not sound like the most innovative tip, but you'd be surprised how many don't use it. If you like a tidy desktop and toolbar, the fastest way to search for a program or options menu is to type directly into the "Start" menu. Left-click the Start menu, and begin to type the name of the folder, program, or options menu you wish to open. "Start" then shows you any program with the name you typed. This works with Cortana disabled by the way, and is available in Windows 7 and 8, too.

MAKE – USE – CREATE

54
Visualize data with Mathematica on a Raspberry Pi

58
Stream your gaming to Twitch with XSplit

66
Build your own GTX 1070 & Core i5 gaming machine

ZAK STOREY
STAFF WRITER

THE JOY OF A GOOD UNDERVOLT

Overclocking is the pinnacle of excellence for the PC enthusiast, as far as I'm concerned. The concept of pushing hardware to its limits is what drove me to get into tech journalism.

But what's the best way to know if you've got a meaty overclocking chip? Surprisingly, the industry consensus is that you need to go the other way first. Whenever I get in a new processor, either for a system or to review, the first thing I do is undervolt it.

Intel always recommends a stock voltage to maintain stability and the advertised frequencies on all of its processors. Unfortunately, it's a conservative recommendation, and the majority of processors can operate at a lower voltage without a problem. The theory then becomes simple: the greater the disparity between Intel's recommendation and the VCore you can run at, the greater the overclocking capacity of your processor is likely to be.

There's another advantage to undervolting your CPU: thermals. The lower the voltage applied to your core, the lower the temperature your core outputs. Take the Core i7-6700K we used in our latest water-cooled build. At stock, it easily hits 52 C under load, but if we undervolt it down to 1.15V, the temperature drops to a much more comfortable 36 C, with zero impact on stability or performance.

↘ submit your How To project idea to: comments@maximumpc.com

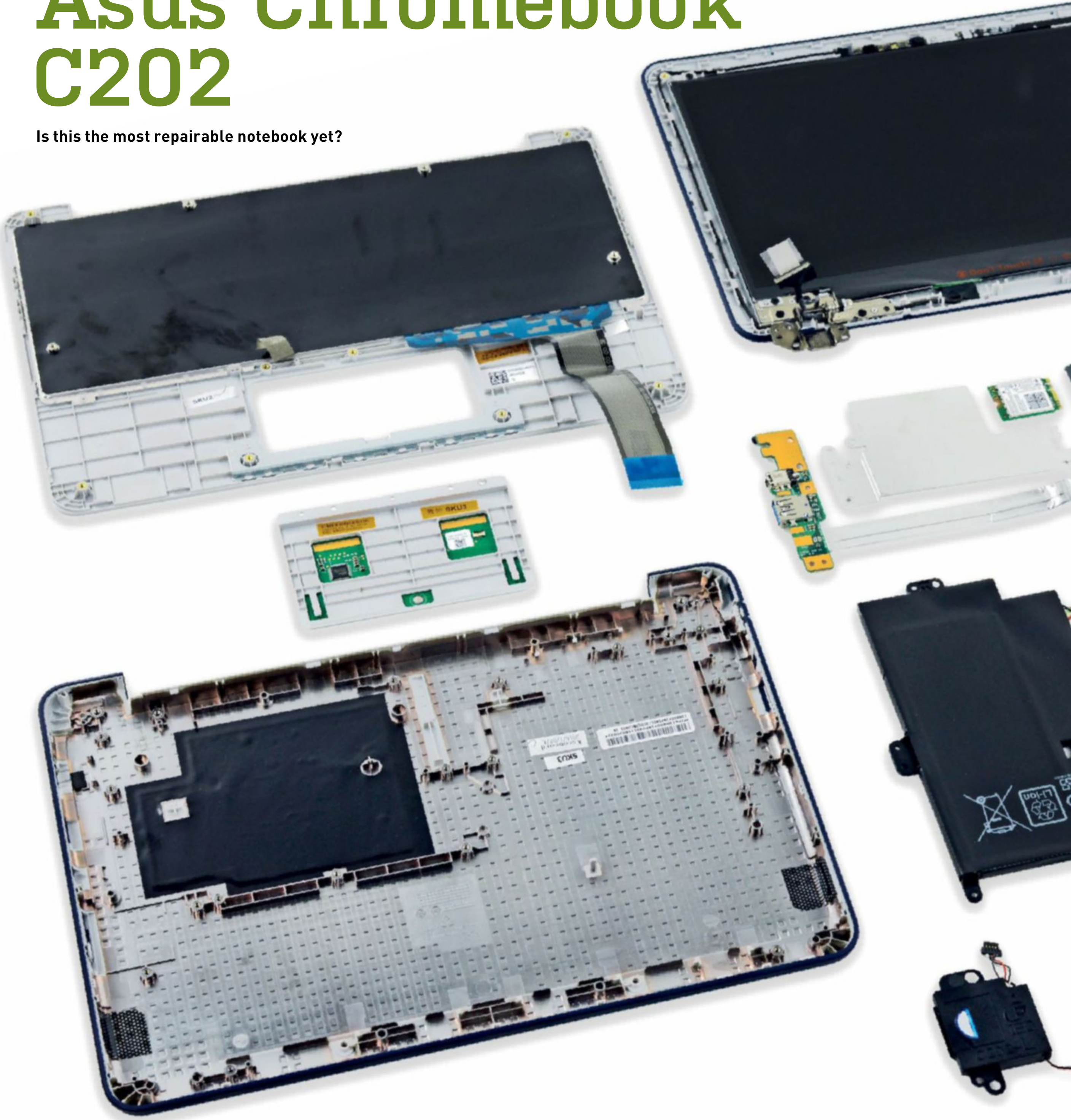
IFIXIT presents:

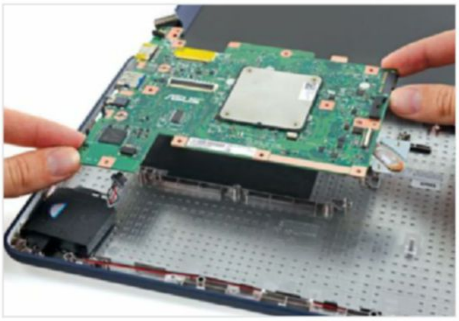
AUTOPSY

THIS MONTH WE DISSECT...

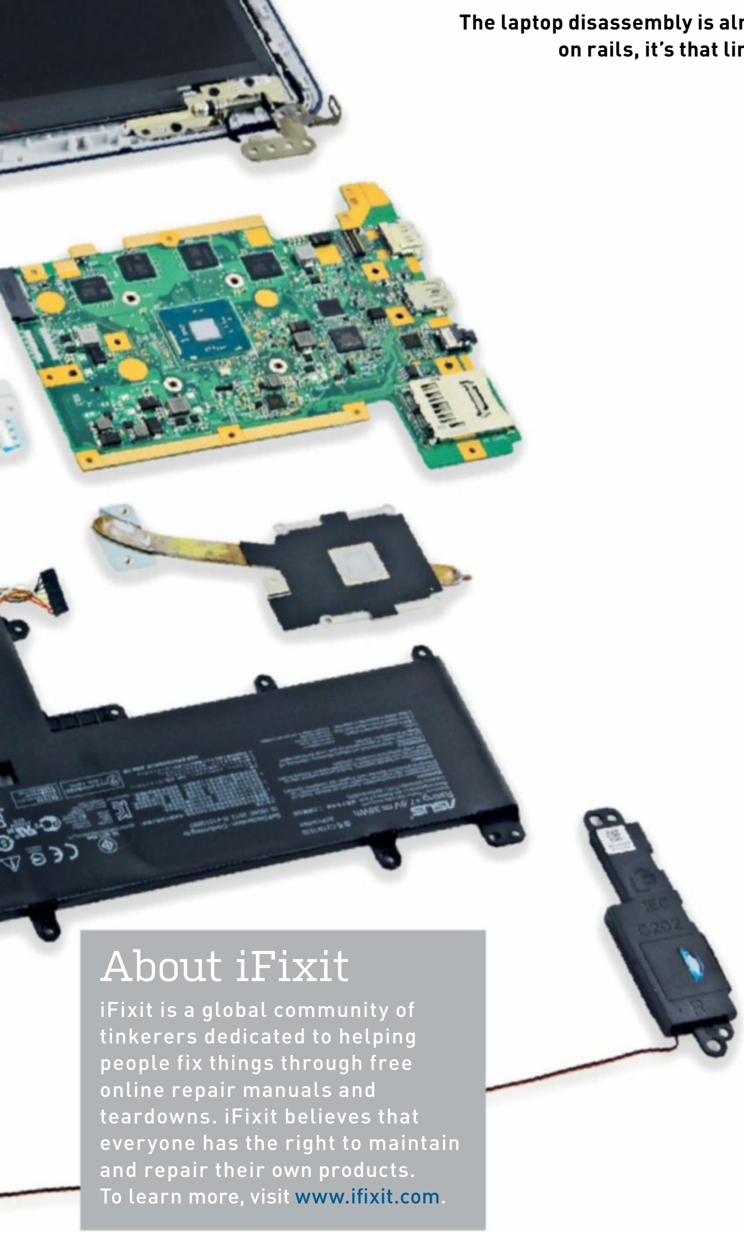
Asus Chromebook C202

Is this the most repairable notebook yet?





The laptop disassembly is almost on rails, it's that linear.



About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

BACKGROUND:

Early this year, Asus announced the Chromebook C202—an education-focused Chromebook designed to be inexpensive, rugged, and highly serviceable. That last bit caught our eye, so when Asus sent a test unit, we eagerly investigated the claim.

MAJOR TECH SPECS:

- Dual-core 1.6GHz Intel Celeron N3060 processor, with burst speeds up to 2.48GHz, and integrated Intel HD Graphics 400
- 2GB and 4GB RAM configurations
- 16GB on-board storage
- HDMI, SD card, and USB 3.0 connectivity
- Chrome OS
- 10-hour battery life
- Ruggedized wrap-around rubber bumper

KEY FINDINGS:

- We grab our tools and get to work. We have to remove a rubber cover or two, but otherwise it's just standard Phillips screws securing the chassis. Plastic clips around the edge of the spill-proof upper case secure it into the bathtub of a lower case—and after a bit of prying, we free them all.
- Keyboard and trackpad ribbon cables connect the upper case to the motherboard, with plenty of slack to flip the upper case over and safely disconnect the ZIF connectors from the motherboard. The trackpad—a common failure point in laptops—practically flies out.
- Having popped the top off, we get a look at the interior. The large interconnect cable even has friendly labeled ends: the side marked "IO" connects to the input/output board, while the side labeled "MB" connects to the motherboard.
- Minor inconveniences suffered, we can remove the battery. Still nothing but Phillips #1 screws to slow us down. Nothing proprietary, and no adhesives. This is a 38Wh lithium-ion battery, on par with the 11-inch MacBook Air's 38.75Wh one.
- Opening up the display is simple. A couple more Phillips #1 screws behind stuck-on covers, and a quick pry reveals the LCD, camera, microphone, antennas, and hinges, ready to be plucked out and replaced.
- Repairability Score: 9 out of 10 (10 is easiest to repair). The intuitive, simplistic design makes disassembly easy and reversible. Modular components mean many repairs can be carried out by quickly swapping a failed part. Only Phillips #1 and #00 screws—no adhesives, and all plastic clips are durable enough to survive reassembly. Linear disassembly means you might have to remove several components to get to what needs replacing. That said, failure-prone parts (battery and ports) are prioritized. RAM and flash storage are soldered to the mobo and can't be replaced or upgraded, but this may not be an issue for the C202's target market.

Visualize Data With Mathematica

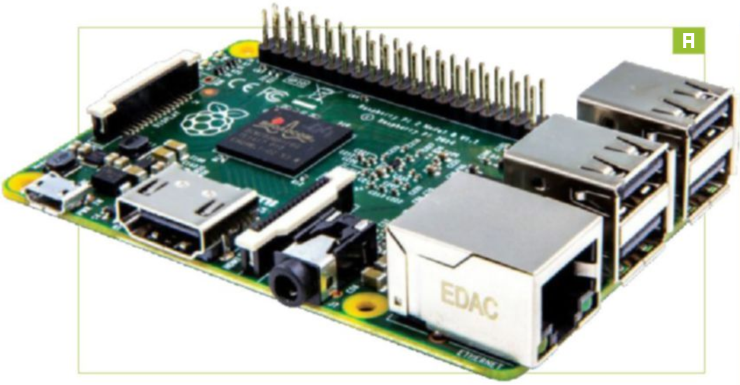
YOU'LL NEED THIS

RASPBERRY Pi 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

MATHEMATICA
Download the Wolfram Language for the Raspberry Pi.

MATHEMATICA IS A FEARFULLY POWERFUL symbolic computation package. It's published by Wolfram Research, and has been on the scene for over 25 years, during which time it has seen heavy adoption by both academia and industry. Powered by the general-purpose Wolfram Language, it provides a simple platform that can solve, simulate, approximate, or decorate pretty much anything you throw at it.

While Raspberry Pi [Image A] users are not usually inclined toward proprietary software (we much prefer free and open source), we make an exception in this case because Wolfram made the decision, in November 2013, to release a free version of Mathematica (and indeed the Wolfram Language) for the Pi. If your views on free software are sufficiently austere, then consider yourself free to not use it. –JONNI BIDWELL



1 INSTALL MATHEMATICA

Still here? OK then, if you have a reasonably new release of Raspbian, there's good news: You already have Mathematica [Image B] installed. If not, you can get it with a simple

```
$ sudo apt-get update
$ sudo apt-get install wolfram-engine
```

›› Make sure you have enough space, though, because the whole install weighs in at about 600MB.

2 UP AND CALCULATING

The package installs two different programs for you: Mathematica and Wolfram Language. Mathematica starts a notebook-style graphical interface, while Wolfram Language starts a terminal-based one. The Wolfram Language is instrumental in powering the Wolfram Alpha knowledge engine, as well as the new Wolfram Programming Cloud. It strives to maximize automation and unification with the goal that, in Stephen Wolfram's own words, "Once a human can express what they want to do with sufficient clarity, all the details of how it is done should be handled automatically." If you're familiar with the package, then beware—to quote Stephen again: "The Raspberry Pi is perhaps 10 to 20 times slower at running the Wolfram Language than a typical current-model laptop, and sometimes even slower when it's lacking architecture-specific internal libraries." In other words, you should prepare to be patient.

3 TRY SOME CALCULATIONS

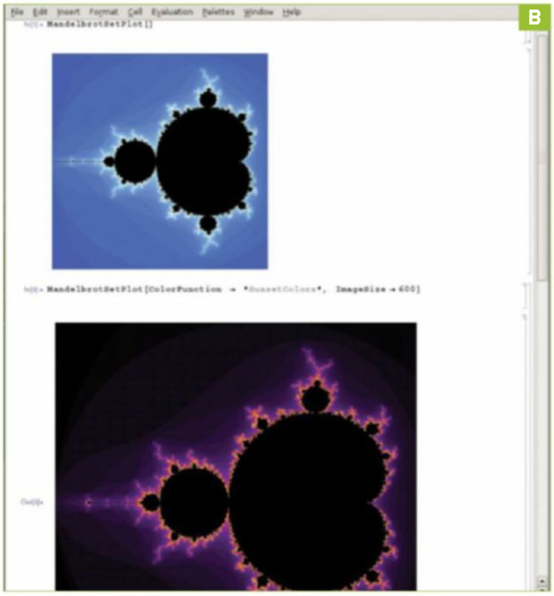
We'll begin by showing the basics of Mathematica. In its most simple form, you can use it as a calculator: Click on the worksheet, and type "3 + 2" (or some other suitably complicated expression) at the "In[1]:=" prompt, press Enter, or select "Evaluate Cell" from the "Cell" menu, and you should see something like "Out[1]=" followed by the correct answer. Naturally, the program is capable of much more taxing calculations. Try "2014 ^ 2013," and be amazed at how quickly the little computer spits out a big answer. It would also be remiss of us not to do something pi-related here, so let's calculate the first million digits of that transcendental:

```
pi = N[Pi, 1000000];
```

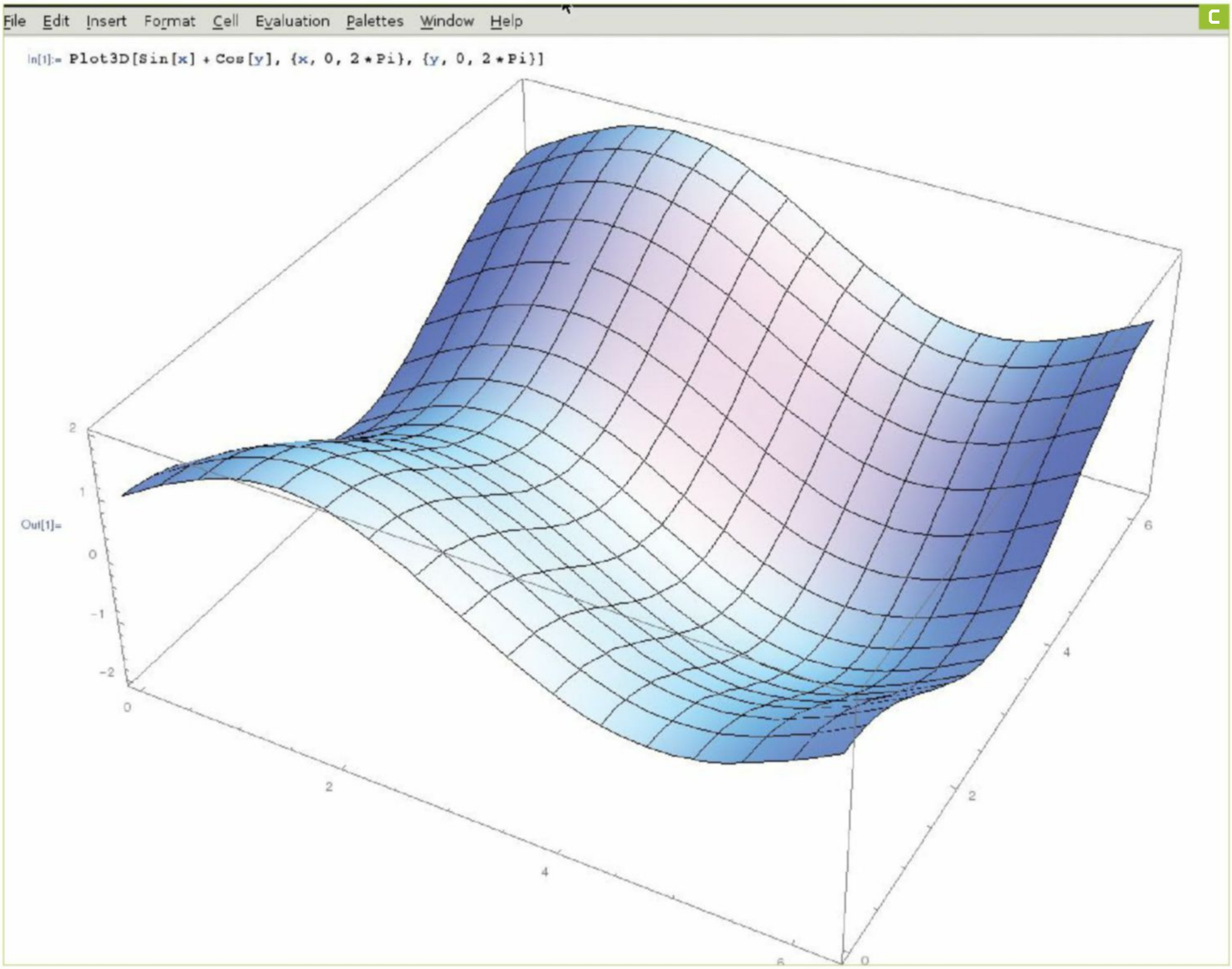
4 DEFINE YOUR OWN FUNCTIONS

On our Raspberry Pi, this took all of 12 seconds (note that the semicolon suppresses outputting this rather lengthy result, which would significantly increase the time taken). We can define our own functions, too; for example, we could make a very naive Fibonacci number implementation like so:

```
F[0] = 0;
F[1] = 1;
F[x_] = F[x -1] + F[x -2];
```


B
File Edit Insert Format Cell Evaluation Palettes Window Help

```
MandelbrotSetPlot[]
MandelbrotSetPlot[ColorFunction → "SunsetColors", ImageSize → 600]
```



```
In[1]:= Plot3D[Sin[x] + Cos[y], {x, 0, 2*Pi}, {y, 0, 2*Pi}]
```

» We use the underscore to indicate that "x" is a user-supplied argument. This function works—we can quickly work out the first terms of the sequence as 0, 1, 1, 2, 3, 5, 8, and so on—but things rapidly grind to a halt when we want to find, say, the thousandth Fibonacci number. You could write a better function, but no need to reinvent the wheel:

```
Fibonacci[1000]
```

swiftly answers your query.

5 NOW FOR EQUATIONS

Remember simultaneous equations from school? Something like solving 2x + 3y = 11 and 3x - y = 0? While this example is child's play, if we have more variables, the situation becomes harder. We form a matrix of coefficients and, if possible, invert it. This is a tedious process to do by hand (using the method of Gaussian Elimination, which has nothing to do with classic Bullfrog title, *Syndicate*), commonly suffered by hungover undergrads, and involving lots of scribbling out. It is also the very same task that a significant proportion of the world's supercomputing time is devoted to, because so many models are based on linear systems.

6 GOING FURTHER

We can solve our basic linear system above (if you haven't already done so) with a simple:

```
m = {{2,3},{3,-1}}
minv = Inverse[m]
minv * {{11},{0}}
```

» Mathematica returns the vector {{1},{3}}, meaning x = 1 and y = 3.

» For no real reason, let's try to make Mathematica invert a 20x20 matrix of random floating point values.

```
m = RandomReal[1,{20,20}]
Inverse[m]
```

» It's nice to visualize the matrix as a rectangular array, rather than a list full of curly brackets. Doing this is a simple question of adding:

```
m // MatrixForm
```

7 TACKLE CALCULUS

Beside linear algebra, Mathematica can help you with your calculus homework. In particular, it's very good at integrating and differentiating things. We use the function call "D[f,x]" to differentiate the function "f" with respect to the variable "x," so you can do something simple, such as:

```
D[cos[x] + x^2, x]
```

which will obtain the solution -sin[x] + 2x. Or you can try something a little harder, such as:

```
D[tan^-1[x^x],x]
```

» You can also find the (lengthy) second and third derivatives of this function using:

```
D[tan^-1[x^x],{x,2}]
```

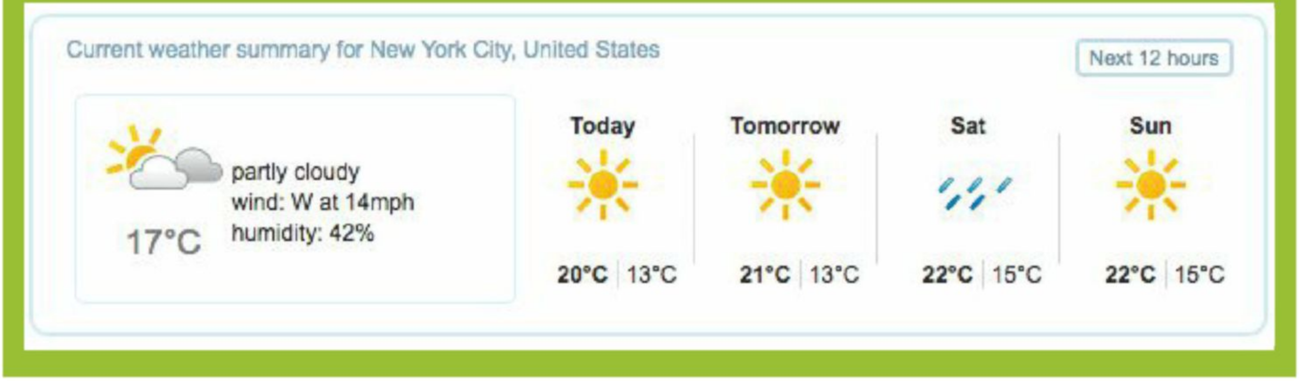
CALCULATE IN THE CLOUD

If the things you want to compute start grinding your Raspberry Pi to a halt or saturating its memory, then it's possible to send certain queries to the Wolfram Alpha knowledge engine, to help solve this issue. Where possible, the responses are sent back in a form that you can continue to work with in Mathematica. Naturally, this requires your Raspberry Pi to be connected to the web.

Wolfram Alpha is capable of understanding natural language queries, as well as those in the Wolfram Language (for example, Mathematica input), so you can ask it about anything you like. For example, rather than risk looking out of the window to see external conditions, we can simply type:

```
WolframAlpha["weather new york us"]
```

Bear in mind that there's a limit to how much free compute time you're allowed, so you won't be able to calculate the answer to life. But the cloud technique is still useful for calculations that intermediately use a lot of memory, but return an easy-to-swallow answer.



Current weather summary for New York City, United States

partly cloudy
wind: W at 14mph
humidity: 42%
17°C

Today	Tomorrow	Sat	Sun
20°C | 13°C	21°C | 13°C	22°C | 15°C	22°C | 15°C

and then:

```
D[tan^-1[x^x],{x,3}]
```

» You can also use the "D[ ]" function to do partial derivatives, or even implicit differentiation:

```
D[x^2 + (y[x])^3,x]
```

» Students often find integration harder than differentiation, and for many years now have been using the online integrator at http://integrals.wolfram.com to do their homework. As you would expect, Mathematica can symbolically integrate pretty much any function where this makes sense (there are exceptions—such as things like x^x, whose integral has no symbolic representation). However, all the elementary functions are handled as you would expect:

```
Integrate[x^2,x]
Integrate[sin^-1[x],x]
Integrate[log[x],x]
```

» Remember: Don't forget the constant of integration. Furthermore, you can even get complicated expressions for things that don't integrate so nicely. For example,

```
Integrate[ln[cos[x]]]
```

evaluates to a rather ugly complex expression involving polylogarithmic functions. One of Mathematica's most impressive capabilities is its ability to produce graphics. Graphs, surfaces, networks, maps are all just a couple of lines away. We can plot a period of the sine function with a simple:

```
Plot[Sin[x],{x,0,2 * Pi}]
```

8

TRACK THE WEATHER

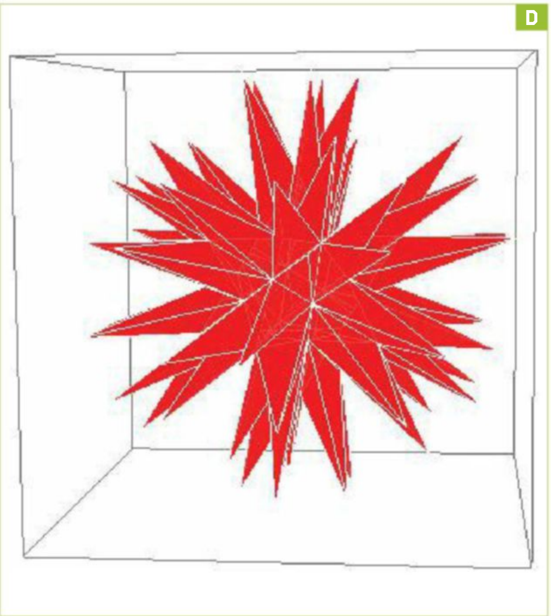
You can also make nice weather charts with Mathematica's built-in "WeatherData[]" function. For example, to plot the daily mean temperatures for the summer:

```
DateListPlot[WeatherData["New York (United States)","
MeanTemperature",{{2016,6,1},{2016,9,1},"Day"}],Joined
->True]
```

» We can even venture into three dimensions, and plot the following function [**Image C**]:

```
Plot3D[Sin[x]+Cos[y],{x,0,2 * Pi},{y,0,2*Pi}]
```

ANOTHER PI TUTORIAL NEXT MONTH


D

» You can draw two (or more) lines or surfaces on the same plot by adding them to the relevant "Plot" function. For example, if you need reminding about how the sine and cosine functions are related:

```
Plot[Sin[x],Cos[x],{x,0,2 * Pi}]
```

» Shapes are easy too, thanks to Mathematica's extensive library of polyhedra. To draw a red echidnahedron [**Image D**], for example, use:

```
Graphics3D[{Opacity[.8], Glow[RGBColor[1,0,0]],
EdgeForm[White], Lighting -> None,
PolyhedronData["Echidnahedron", "Faces"]}]
```

(And if you've never heard of an echidnahedron, it's an icosahedron stellation having 92 vertices, 270 edges, and 180 faces—of course!)

9 RASPBERRY SPECIAL

For the most part, the Raspberry Pi edition of Mathematica is a diet version of the full-fat product. However, it does have a number of features that are exclusive to this version, namely the ability to talk to devices connected via the GPIO pins, and the CSR-connected PiCam module. All of this invocation happens through the "DeviceRead" and "DeviceWrite" commands. For example, to set pin 14 to high:

```
DeviceWrite["GPIO", 14 -> 1]
```

Replace "1" with "0" to set it to low. To read the status of GPIO pin 14 (GPIO14 in the BCM numbering—take care), do:

```
status = DeviceRead["GPIO", 14]
```

and the variable status will take on the value "0" or "1," as appropriate. You can import an image from the camera module into Mathematica as follows:

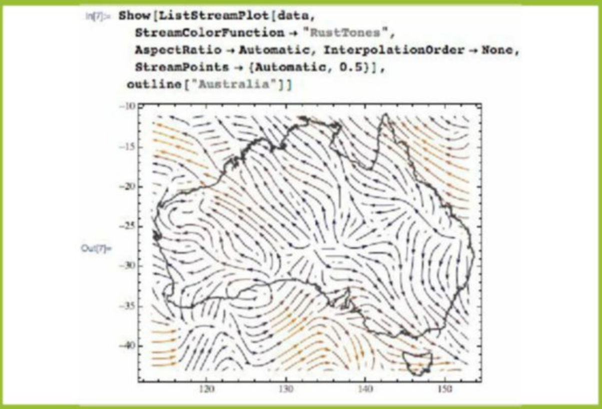
```
img = DeviceRead["RaspiCam"]
```

» And then you can export it as a JPEG, or whatever format you like, using the following:

```
Export["/home/pi/img.jpg", img]
```

» And here we end our quick journey through the Pi edition of Mathematica.

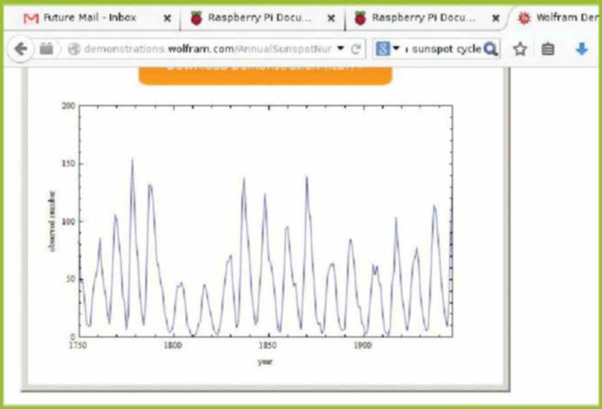
THINGS TO TRY WITH MATHEMATICA



```
In[7]:= Show[ListStreamPlot[data,
          StreamColorFunction → "RustTones",
          AspectRatio → Automatic, InterpolationOrder → None,
          StreamPoints → {Automatic, 0.5}],
         outline["Australia"]]
```

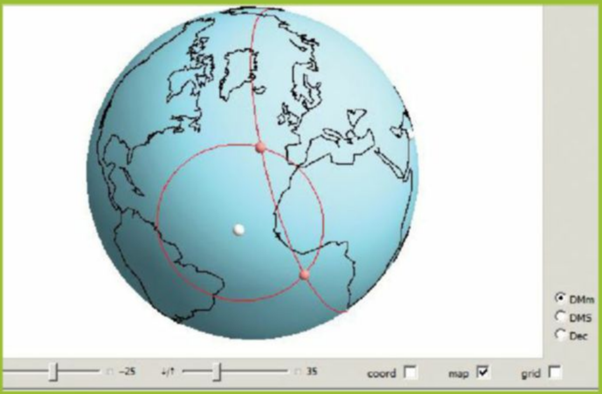
1. STREAM PLOT

Here is a stream plot that shows the directions of wind across Australia. The higher wind speeds are represented by brighter colors. To do this yourself, the outline function needs to be manually entered, but you can find all the details on how to do this on the Wolfram blog. Stream plots are commonly used to visualize differential equations (http://bit.ly/WeatherPatterns).



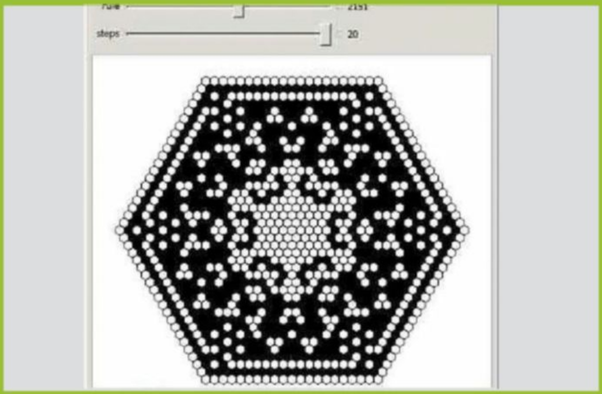
2. SUNSPOT CYCLE

Witness the 11-year sunspot cycle, using publicly available data. Between 1640 and 1710, there were abnormally few sunspots, which coincided with the European "mini ice age." In general, if you're looking for frequencies in noisy data, a good trick is to convolve your data with a moving average kernel, to smooth it out before using Fourier analysis (http://bit.ly/SunspotNumbers).



3. CELESTIAL NAVIGATION

An old Maori proverb says, "Before you embark on a journey, make sure you know the stars." Here, you can get your bearings by measuring the angles of altitude to planets, stars, or the moon at a specific time. The celestial sphere is approximated by Earth moving through a circular orbit at constant speed, otherwise things get ugly (http://bit.ly/CelestialNavigation).



4. SNOWFLAKES

Cold outside? Have a play with some different kinds of snowflakes. This one is generated using hexagonal cellular automata. All snowflakes exhibit hexagonal symmetry, due to hydrogen bonding in water molecules. When they freeze, the crystals are formed into a hexagonal arrangement, because of the layout of the charges (http://bit.ly/SnowflakeLikePatterns).

Stream Your Gaming With XSplit

YOU'LL NEED THIS

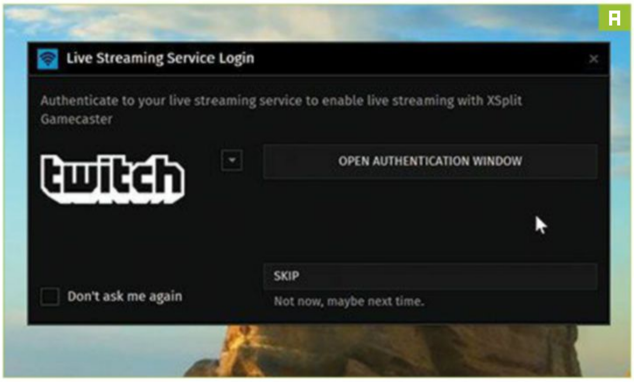
A TWITCH ACCOUNT
Register at www.twitch.tv.

XSPLIT GAMECASTER
Download from www.xsplit.com.

HEADSET, WEBCAM, PC, AND ONLINE CONNECTION
This takes a lot of CPU power.

GAME STREAMING IS A SERIOUS BUSINESS. For some people, it's actually possible (though improbable) to make a living sitting in front of your PC, thanks to the generosity of viewers, and Twitch's numerous partnership schemes. We're not here today to teach you those particular secrets, though. We're working on the most important step: getting yourself out there in a presentable, watchable manner.

It's worth mentioning here that this tutorial doesn't only work for Twitch, though that's the service most people use—you can also use XSplit Gamecaster to send your various embarrassing misplays and goofups to Hitbox, YouTube Live, and a number of other services. We'll show you how to add additional accounts. And we're working with the basic version of XSplit here; picking up a license (from $2.50 per month) will add heaps of extra features, and enable 1080p streaming without a watermark, so it's worth considering if you're picking up streaming steam. **–ALEX COX**


A
Live Streaming Service Login
twitch
OPEN AUTHENTICATION WINDOW
SKIP
Not now, maybe next time.
Don't ask me again

Authenticate to your live streaming service to enable live streaming with XSplit Gamecaster

1 DOWNLOAD AND INSTALL

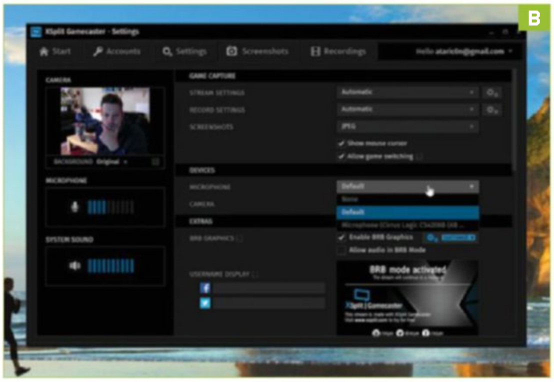
We'll begin with the obvious setup steps, and not go into huge detail because, hey, you can handle it, champ. Register a Twitch account at www.twitch.tv, register an XSplit account at www.xsplit.com, then follow the links in your email to activate these accounts. Download XSplit Gamecaster and install it—if your machine is missing any of the prerequisites it needs, it grabs them and installs them for you, so make sure you're online while you install. Run Gamecaster for the first time, and you're given the option to connect to your streaming service [Image A]. Twitch is selected by default, so click "Open Authentication Window," log in, and click the "Authorize" button to share the relevant security keys from your account with XSplit.

2 YOUR FIRST STREAM

Once Gamecaster has fully run, you're already set to pull off a basic stream—simply open your chosen game, hit Ctrl-Tab to see the XSplit overlay, then hit "Stream" to begin sending your video to Twitch. XSplit automatically works out the optimal bitrate, based on your network connection. Switch away from your game, and XSplit displays a default BRB message to your viewers—this is a limitation of the free version, so if it bugs you, you should think about upgrading.

3 HARDWARE TIMES

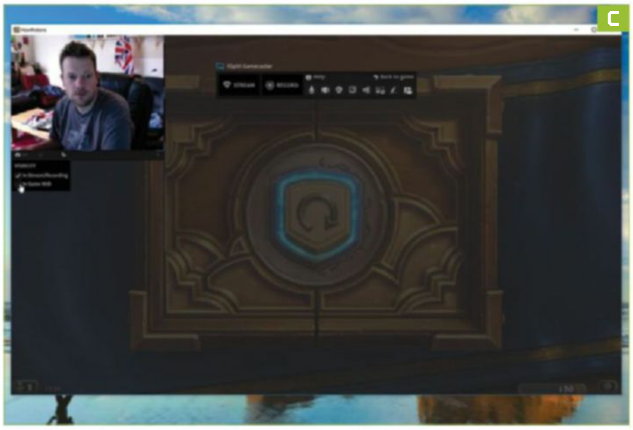
Quit your game for now (this stops the streaming automatically), and head back to the Gamecaster interface, so we can make sure it's using the correct hardware to do its thing [Image B]. In "Settings/Devices," use the drop-down box to ensure it's using the correct microphone for your headset—we wouldn't recommend using, say, a laptop mic, just for the sake of those watching—and check that your webcam is hooked up, too. You should see a preview in the top-left of the window if it is. You can also tweak the audio levels that go out to your stream here—although, because these settings are also available through the XSplit overlay, you may be better altering them there, based on the feedback of your viewers.



STREAM SETTINGS Automatic
RECORD SETTINGS Automatic
SCREENSHOTS JPEG
✓ Show mouse cursor
✓ Allow game switching
MICROPHONE Default
✓ Enable BRB Graphics
☐ Allow audio in BRB Mode

4 ADD YOUR CAMERA

What would game streaming be if your viewers couldn't see the look on your face as you get destroyed for the 32nd time? It would be rubbish. Thankfully, Gamecaster makes adding a camera to your stream a trivial matter. Go back to your game (you don't have to resume streaming just yet), hit Ctrl-Tab to bring up the overlay, and click on the camera icon to plop your webcam on top of your game. Now drag the edges to resize it, and drag the center to place it where you want it, trying not to cover up anything important. It can be tough to play games with the self-conscious feedback loop caused by staring at your own face, but you can choose to have the cam only appear to stream viewers, thankfully. Hover your mouse over the bar on the edge of the webcam [Image C] and find the visibility icon, then switch off "In Game HUD" to have it only appear to stream viewers.

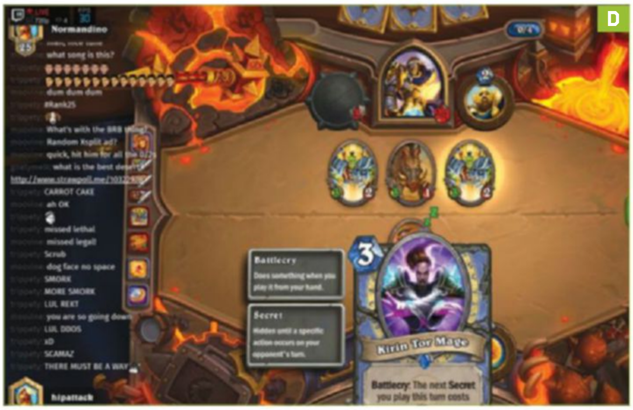

C

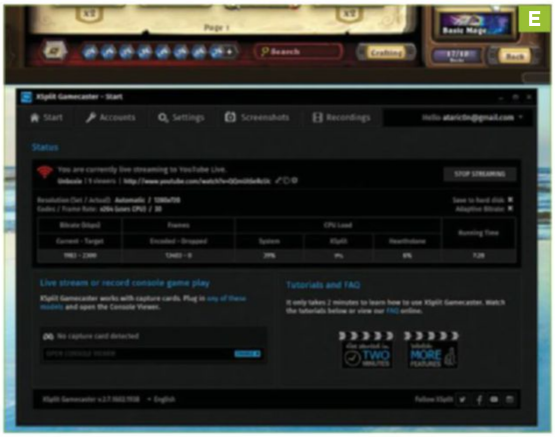
5 KEEP UP WITH CHAT

Let us flip the principle we just used to hide the webcam while playing, in order to introduce a layer that only we can see. Twitch chat, 30-second delay or not, is a vital part of staying connected to your audience, and if you're running full-screen, or don't have the luxury of multiple monitors, Gamecaster's chat overlay is vital. Open the overlay with Ctrl-Tab, hover over the Twitch icon, and click the second icon down to show the Twitch chat panel. Find the visibility icon, and this time set it to only display on the in-game HUD. It's also worth dropping the opacity of the window somewhat (take it all the way to zero to only see the chat messages), and repositioning it so it's not covering vital areas of gameplay [**Image D**]. If you want to send messages while you're playing, just open up the overlay as usual, and type into the gray box at the bottom of the chat window. Finishing your message with Shift-Enter closes the overlay automatically when you've finished typing.

6 STREAMING PROPER

By now, you'll have your layout locked down. Just a couple of things to do: set the title of your stream, and tell people you're online. Hover over the Twitch icon, and hit the cog to customize your title—XSplit will have automatically matched up the game you're playing with a game in Twitch's extensive database. The next icon along enables you to share to Facebook and Twitter—click each icon to authorize your account, as you did with your Twitch account earlier on, then hit "Share" to send the message out.


D


E

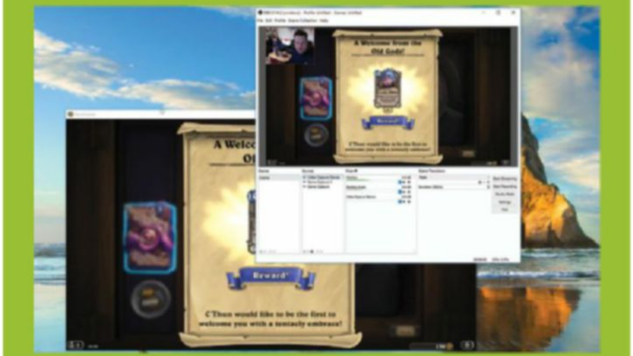
7 MOVING HOME

Provided your YouTube account is in good standing, you can stream your gameplay via YouTube Live instead of Twitch. Head back to the Gamecaster app, go to the "Accounts" tab, and click the drop-down arrow to the right of your Twitch account. Select "YouTube Live," and authorize the account as before. You may need to accept YouTube Live's terms of service before you can complete this step; Gamecaster gives you a link if that's the case. When you begin streaming, enter your stream info into the box provided—you can't change this on the fly as with Twitch—and be sure to change the status from "Unlisted" to "Public" if you want your channel's subscribers to see that you're streaming.

8 SEE YOUR STATUS

While streaming, keep half an eye on the "Start" tab of the Gamecaster window. It keeps you informed of your current bitrate, any dropped frames, and the load on your system from your game, XSplit, and overall [**Image E**]. If these numbers creep too high, you may need to drop your bitrate manually by going to "Settings," clicking the "Automatic" box next to "Streaming," selecting "Custom," and dialing in your own options. Happy streaming! ⏻

THE OBS ALTERNATIVE



While XSplit hides many of its features behind its subscription fees, Open Broadcaster Software (www.obsproject.com) is a free, open source way to get your footage streaming online. It's less user-friendly than Gamecaster, and there's a reason the majority of streamers favor XSplit, but OBS might be a good move before stumping up the cash. It structures itself into scenes and sources, which you need to create before you can start streaming. A single scene can contain multiple sources—images, games, webcams—and setting up multiple scenes before streaming means you can transition smoothly between them. Grab OBS Studio for the most up-to-date version; it's still in development, but it works just fine.

Create Black and White Images

YOU'LL NEED THIS

PHOTOSHOP
Or Photoshop Elements.

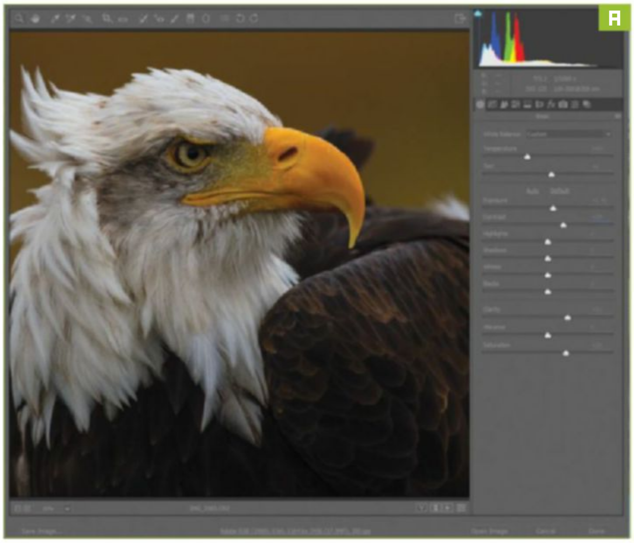
NIK COLLECTION
Download the plugins from www.google.com/nikcollection.

A SUITABLE IMAGE
Many pics benefit from this trick.

ONCE, ALL PHOTOS WERE BLACK AND WHITE. It wasn't until 1935, when Kodak introduced Kodachrome film, that color photography became remotely mainstream. When shooting with black and white film, a photographer needs to be able to mentally picture the finished image in all its shades of gray, and the better you're able to do that, the better your final picture will be.

Today, black and white photography still thrives. Thanks to the likes of Instagram, it's never been easier to change color photos to black and white, and add processing artefacts that would once have taken hours to achieve. Rather than use the same one-shot filters as everyone else, however, why not cook up your own in? It's straightforward to create striking and unique looks.

While it's possible to set many digital cameras to produce monochrome images, once you've discarded the color information in-camera, it's gone for good. Much better to shoot in color, then manage the conversion to black and white on your PC. **–IAN EVENDEN**



1

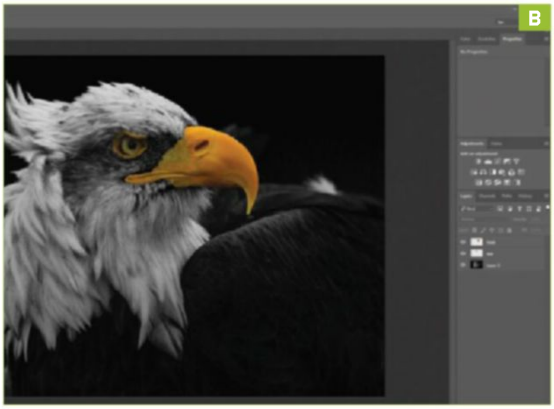
OPEN YOUR RAW FILE

We're starting with a raw file, so have opened it in Camera Raw [**Image A**]. You could do the same thing in Lightroom, or any other raw image processor if you wanted. We're increasing the contrast at this point, but if you're working with a JPEG, you could do the same thing with the Levels window, stretching the histogram so the tones are mapped as widely as possible.

2

LIGHTEN AND DARKEN

Photoshop, of course, has its own built-in black and white conversion tool ("Image → Adjustments → Black and White"). Open it up, and your photo pops into monochrome, and you're presented with a panel of color sliders. This may appear counter-intuitive, until you consider how black and white photography works. Or worked, at any rate. Photographers would place colored filters over their lenses, the effect of which was to lighten that color in the resulting image, and darken its opposite—indeed, there's a preset menu that emulates these filters. In our image, the eagle has a beak that's a similar color to the background, so if we want to darken the background, by pulling the yellow slider to the left—the equivalent of a blue filter over the lens—we're going to darken the beak, too.



3

WORK ON A NEW LAYER

To get around this, we use the Quick Selection tool to select the yellow beak and eye areas, and copy them to a new layer with "Layer → New → Layer Via Copy" [**Image B**]. This enables us to work on them separately because, despite being on the Image menu, Photoshop's black and white conversion only applies to the currently selected layer, not the whole file. Once you're happy, give it a heavy sharpening with the Unsharp Mask tool [**Image C**], then flatten the image and save it. Done, in less than half the length these tutorials normally run for.

4

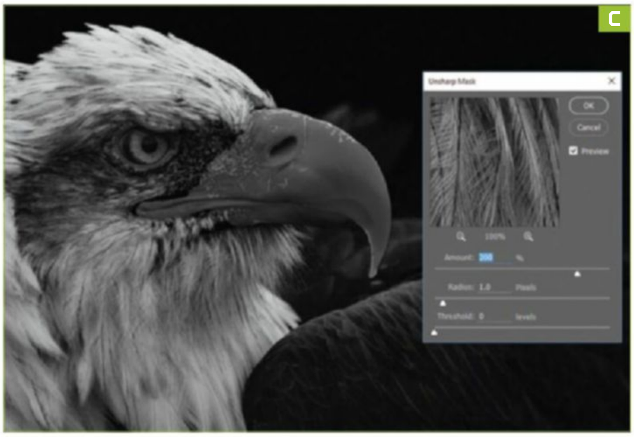
DOWNLOAD NIK COLLECTION

Interestingly, however, Google's Nik Collection of Photoshop and Lightroom plugins became free earlier this year, and that means the excellent Silver Efex Pro 2 is now easily within every Photoshop, Lightroom, or Elements owner's reach. It's about a 430MB download from www.google.com/nikcollection, and easily installed by running the .exe file. The next time you run your image-editing app, there'll be a new floating palette right in the middle of the screen, looking like it doesn't belong there. It can be easily minimized and moved off to one side, however.

5

ADD SOME BLEMISHES

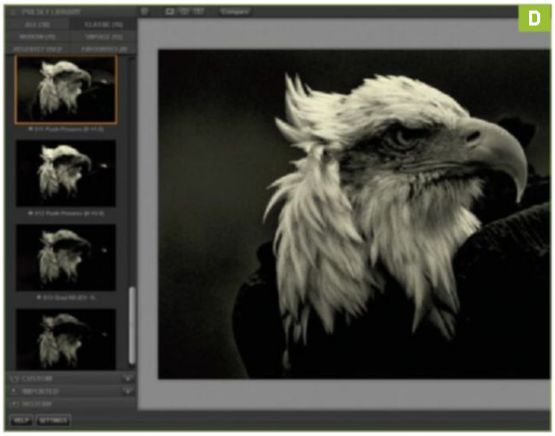
Before we explore Silver Efex, let's first look at Analog Efex, the Nik Collection's film and camera



Amount: 200 %

Radius: 1.0 Pixels

Threshold: 0 levels



simulation plugin. Selecting the "Analog Efex Pro 2" option on the palette opens the plugin. It's GPU-accelerated (GTX 400/Radeon HD series or above), but even so, can take several seconds to analyze your image. Use the "Cameras" menu at the top-left to select black and white options, then scroll through them. We like the sepia tones of filter number seven, but choose whatever suits your image best. Once you've chosen a filter, you can move to the right to further edit it. It placed a number of dust spots and scratches over our image, which turned out to be caused by a "frame" around it, rather than the "Dirt and Scratches" menu. There's a huge number of ways available to ruin your photo, each with a strength slider that can be pushed to the right to make scratches in black, or to the left to render them in white.

6 EXPERIMENT WITH EFFECTS

When you're done playing with Analog Efex, use Photoshop's History palette to return your image to its original state, then it's time to look at Silver Efex. Once it opens, you'll find one-shot filters for quick adjustments on the left, while on the right are controls for manual and selective adjustments—it's very similar to Analog Efex. One of the nicest features of the Nik Collection is that once you press "OK" on a filter or edits, they're applied as a separate layer, on top of your original one, so you're free to blend the two together in any way you choose. We found that blending our mono and color images together using the Multiply blend mode gave us a very high-contrast but still colorful look.

7 FINAL TOUCHES

For a really gritty, high-contrast, black and white result, some of Silver Efex's push process presets are perfect [**Image D**]. Mix these with the "Film Types" menu on the right, and you can get a very authentic-looking result. We chose an ISO 1600 Fuji Neopan Pro film and a yellow filter, then added a bit of lens fall-off around the edges for an image that looks like it was taken a long time ago, and roughly treated in the meantime. A tiny bit of sepia toning, then additional darkening with Photoshop's Levels tool, finishes it off. Remember to save as a PSD file to retain the layers for further editing. ⏻

SHADES OF GRAY

Despite being changed to black and white, the images produced using the techniques we've outlined here are actually still color. Each pixel has R, G, and B values. To make it truly monochrome, you'd need to head to the "Image" menu and change the mode to "Grayscale," which discards all color information and makes for a much smaller file once you save it. This does, however, remove any split-toning or sepia you've added to your black and white image, so isn't the best choice in every situation. Changing a file to Grayscale, then back to RGB, however, gives you a good starting point for adding color effects to a black and white image. Just make sure you save the color original first.

Fix Audio Issues in Windows 10

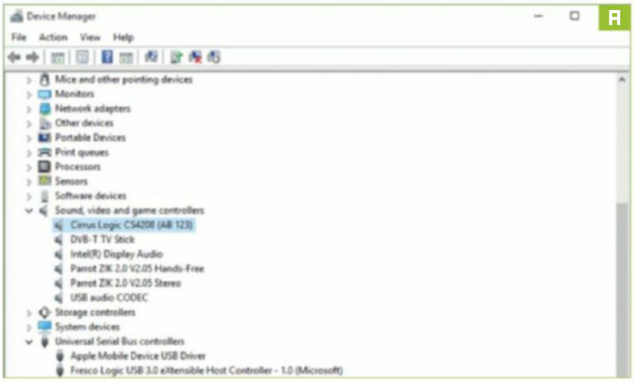
YOU'LL NEED THIS

WINDOWS 10
All these steps can be followed within the OS itself.

FOR ALL THE BENEFITS that come with upgrading to Windows 10, there have been reports that some people have experienced problems with sound output, leaving them unable to enjoy movies or hear anything at all from their PC's speakers.

For example, users whose PCs have VIA HD Audio have found they can only hear sound from certain apps. Fortunately, there's a workaround if you're affected by this issue. Right-click "Playback Devices," right-click the audio output device, and set it as the default device. Then select the device with your left mouse button, choose "Properties," select the "Enhancements" tab, and check "Disable all enhancements." That should fix the problem.

For everyone else with audio issues, try the following steps. You'd be surprised at how effective they can be. **–TIM HARDWICK**



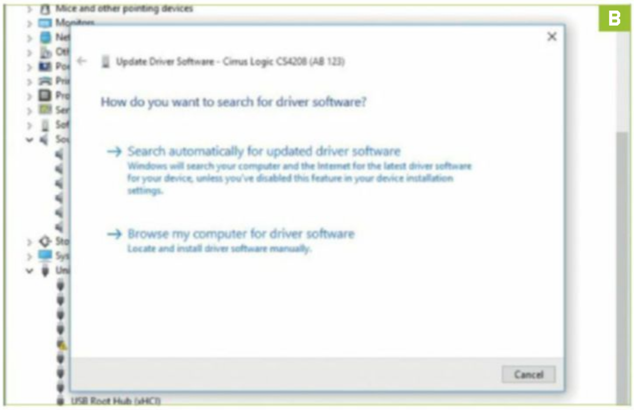
Mice and other pointing devices
Monitors
Network adapters
Other devices
Portable Devices
Print queues
Processors
Sensors
Software devices
Sound, video and game controllers
  Cirrus Logic CS4208 (AB 123)
  DVB-T TV Stick
  Intel(R) Display Audio
  Parrot ZIK 2.0 V2.05 Hands-Free
  Parrot ZIK 2.0 V2.05 Stereo
  USB audio CODEC
Storage controllers
System devices
Universal Serial Bus controllers
  Apple Mobile Device USB Driver
  Fresco Logic USB 3.0 eXtensible Host Controller - 1.0 (Microsoft)

1 DRIVER ISSUES

The most common sound problems are due to users not updating the device driver for their PC's soundcard or audio chip. Open the "Start" menu, and type "Device Manager." Launch the utility by clicking it, and you'll see a list of icon options. Choose "Sound, video, and game controllers" [**Image A**]. If your PC has a soundcard, you'll see it here. Click the card profile to open it.

2 UPDATE DRIVER

Next, click the "Driver" tab and look for the option to "Update Driver" [**Image B**]. Select it, and Windows starts to search for the correct driver online, then downloads it. If the search comes up empty, visit your soundcard manufacturer's website to find the applicable driver to download. Once the driver update is complete, restart your PC, and check whether the issue has been resolved.

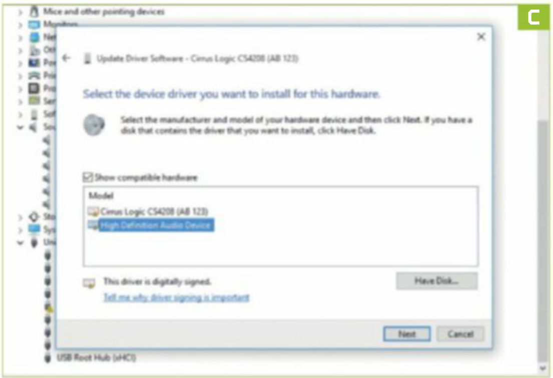


Update Driver Software - Cirrus Logic CS4208 (AB 123)

How do you want to search for driver software?

→ Search automatically for updated driver software
Windows will search your computer and the Internet for the latest driver software for your device, unless you've disabled this feature in your device installation settings.

→ Browse my computer for driver software
Locate and install driver software manually.



Update Driver Software - Cirrus Logic CS4208 (AB 123)

Select the device driver you want to install for this hardware.

Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver that you want to install, click Have Disk.

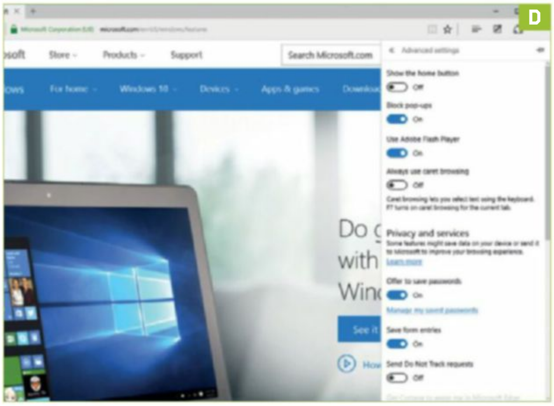
☑ Show compatible hardware

Model
Cirrus Logic CS4208 (AB 123)
High Definition Audio Device

This driver is digitally signed.
Tell me why driver signing is important

3 GENERIC DRIVER

If updating your soundcard driver fails to fix the problem, try Windows' generic audio driver. Open Device Manager, right-click your soundcard, and choose "Update driver software." Choose "Browse my computer for driver software," then select "Let me pick from a list of device drivers on my computer." Click "High Definition Audio Device" from the list [**Image C**], click "Install," and restart your PC.



Advanced settings

Show the home button
Off

Block pop-ups
On

Use Adobe Flash Player
On

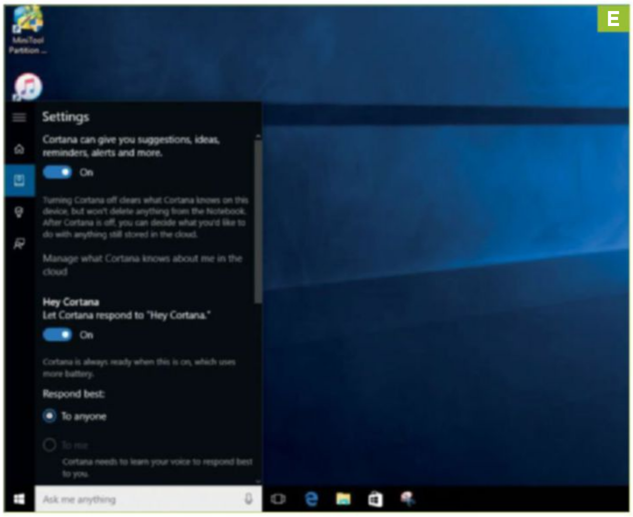
Always use caret browsing
Off
Caret browsing lets you select text using the keyboard. F7 turns on caret browsing for the current tab.

Privacy and services
Some features might save data on your device or send it to Microsoft to improve your browsing experience.
Learn more

Offer to save passwords
On
Manage my saved passwords

Save form entries
On

Send Do Not Track requests
Off



Settings

Cortana can give you suggestions, ideas, reminders, alerts and more.

● On

Turning Cortana off clears what Cortana knows on this device, but won't delete anything from the Notebook. After Cortana is off, you can decide what you'd like to do with anything still stored in the cloud.

Manage what Cortana knows about me in the cloud

Hey Cortana
Let Cortana respond to "Hey Cortana."

● On

Cortana is always ready when this is on, which uses more battery.

Respond best:

● To anyone

○ To me
Cortana needs to learn your voice to respond best to you.

Ask me anything

4 BROWSER ISSUES

If your sound issue is restricted to not being able to hear sound online when using Edge, it could be a problem with Adobe Flash Player. Open the Edge browser, and you'll see a button in the top corner of the window, with three dots in it. Click this, select "Settings," then "Advanced Settings" at the bottom of the list. Ensure the toggle is on next to "Adobe Flash Player" [Image D].

5 CORTANA WON'T LISTEN

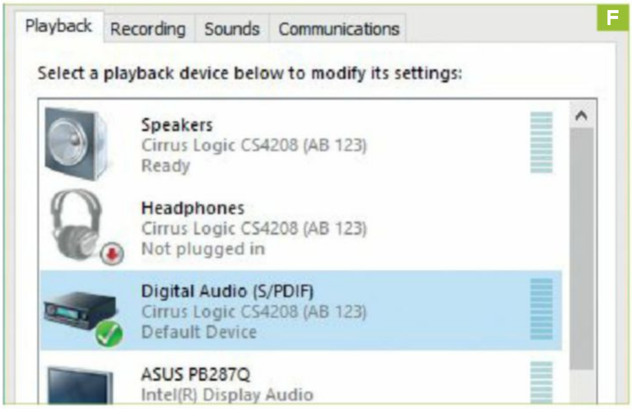
When enabled, Microsoft's voice assistant, Cortana, is meant to listen to your commands upon hearing the words "Hey, Cortana." If it isn't hearing you, make sure your PC's microphone is on. Also, check the settings—open Cortana, select the Notebook icon, and then "Settings." Make sure the option for Cortana to listen for "Hey, Cortana" is turned on [Image E].

6 CHECK CABLES

Check your speaker and headphone ports for loose cables or the wrong jack, and flex the wires to see whether there's a poor connection. Also, check your power, and try turning the volume controls up. Some speakers and apps have their own volume controls, so you might have to check them all. Remember, your speakers are probably set to go off when your headphones are plugged in.

7 SET DEFAULT DEVICE

If you're connecting to an audio device using USB or HDMI, you might need to set that device as the default before you hear anything. To do so, open the "Start" menu, type "Sound" into the search box, and select it from the list of "Settings" results. Next, click the "Playback" tab, select the device you're trying to connect, and click "Set Default" [Image F]. If this doesn't work, connect the device to another port.



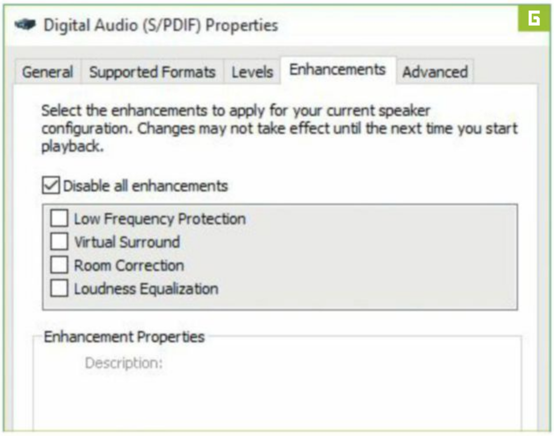
Select a playback device below to modify its settings:

Speakers
Cirrus Logic CS4208 (AB 123)
Ready

Headphones
Cirrus Logic CS4208 (AB 123)
Not plugged in

Digital Audio (S/PDIF)
Cirrus Logic CS4208 (AB 123)
Default Device

ASUS PB287Q
Intel(R) Display Audio



Select the enhancements to apply for your current speaker configuration. Changes may not take effect until the next time you start playback.

☑ Disable all enhancements

☐ Low Frequency Protection
☐ Virtual Surround
☐ Room Correction
☐ Loudness Equalization

Enhancement Properties

Description:

8 BAD ENHANCEMENTS

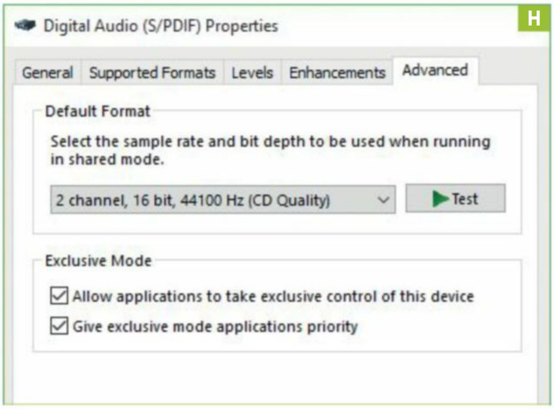
Occasionally, the issue can lie with the audio enhancements that Microsoft or third parties have designed. Happily, you can turn them off. Open "Start," type "Sound" into the search box, and select "Sound Control Panel" from the list of "Settings" results. Select the "Playback" tab, right-click the "Default Device," and choose "Properties." On the "Enhancements" tab, check "Disable all enhancements" [Image G].

9 CHANGE AUDIO FORMAT

Sometimes, incompatible drivers or third-party audio software can affect playback, so check if an audio format is the source of your problem. In the "Sound" control panel, select "Playback," right-click the "Default Device," and choose "Properties." Select "Advanced," and change the setting under "Default Format" [Image H], then retest your audio. If that doesn't work, try another format.

10 TROUBLESHOOTER

If all other efforts fail to solve the problem, try Windows 10's native audio troubleshooter. Occasionally, it can resolve an issue you're having. To run it, open "Start," type "troubleshooting" into the search box, and select it from the "Settings" results. Then, under "Hardware and Sound," click "Troubleshoot audio playback," and click "Next" in the window that appears. ⏻



Default Format

Select the sample rate and bit depth to be used when running in shared mode.

2 channel, 16 bit, 44100 Hz (CD Quality)

Exclusive Mode

☑ Allow applications to take exclusive control of this device
☑ Give exclusive mode applications priority

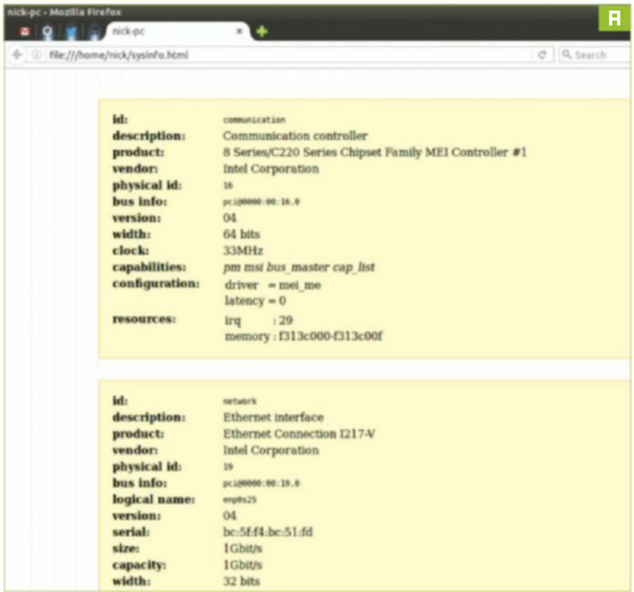
Linux Basics: Get System Info

YOU'LL NEED THIS

LINUX
Ubuntu, or another Debian-based distro.

REGARDLESS OF WHAT LINUX DESKTOP you use, beneath it all lies the shell, a command-line interface that gives you unparalleled access to your PC. If you're new to Linux, there are many different ways in which you can immerse yourself in the Terminal, and learn practical new skills; in this tutorial, we're covering how to get key information about the inner workings of a system running Ubuntu (or another Debian-based distribution).

There are plenty of system information tools accessible through your Unity desktop environment, but they're scattered here and there, and rarely offer much in the way of detailed information. By contrast, the Terminal offers a number of useful commands that give you lots of the detail you're missing from the Unity desktop. –**NICK PEERS**



```
id:             communication
description:    Communication controller
product:        8 Series/C220 Series Chipset Family MEI Controller #1
vendor:         Intel Corporation
physical id:    16
bus info:       pci@0000:00:16.0
version:        04
width:          64 bits
clock:          33MHz
capabilities:   pm msi bus_master cap_list
configuration:  driver  = mei_me
                latency = 0
resources:      irq     : 29
                memory : f313c000-f313c00f

id:             network
description:    Ethernet interface
product:        Ethernet Connection I217-V
vendor:         Intel Corporation
physical id:    19
bus info:       pci@0000:00:19.0
logical name:   enp0s25
version:        04
serial:         bc:5f:f4:bc:51:fd
size:           1Gbit/s
capacity:       1Gbit/s
width:          32 bits
```

1 GET A HARDWARE SUMMARY

The first tool worth looking at is `hwinfo`. Note: This has been depreciated, but can still provide a useful summary of the hardware attached to your system, particularly when you pair it with this flag: `hwinfo –short`.

» When used, you'll see a handy list of your hardware: its type, followed by a description that usually includes manufacturer and model number. Now let's delve deeper.

» There is a number of commands prefixed with `ls` that provide all the detail you need about your system. The first is the universal `lshw` command, which provides every scrap of detail you might (or might not) need about your system. Note that it needs to be run as an administrator, so invoke it using `sudo` — `sudo lshw`. You'll see various parts of your Linux box are scanned before a lengthy—and seemingly exhaustive—list of system information is presented. Trying to digest all of this at once can be tricky, but you can output this information as an HTML file [**Image A**], for reading (and searching) more easily in your web browser, with `sudo lshw -html > sysinfo.html`.

» The file is generated wherever you currently are in the Terminal, and in your Home folder by default. Like `hwinfo`, it can also provide a more digestible summary via `sudo lshw -short`. This basically provides a table-like view of your system, with four columns to help identify your hardware: H/W path, Device, Class, and Description.

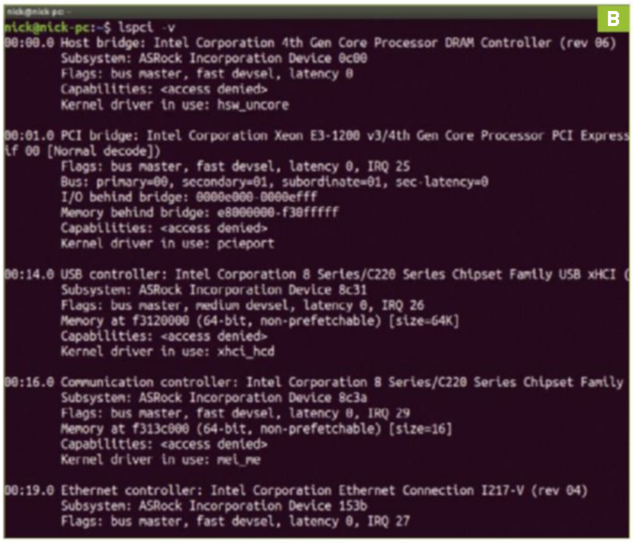
2 THE LS FAMILY

If you're looking for targeted information about a specific part of your computer, you'll want to look into other members of the `ls` family. Start with the `lscpu` command, which provides you with detailed information about your processor, including useful snippets such as the number of cores, architecture, cache, and support for hardware virtualization.

» Next up are your storage devices, and you can start by trying `lsblk`. This lists all of your block storage devices, which covers your hard drives, DVD drives, flash drives, and more. Key information includes its "name" (basically, information about the physical drive and its partitions—sda, sdb1, and so on), size, type (disk or partition, but also "rom" for CD, and "lvm" if you have Logical Volume Management set up), and where the drive is mounted in the Linux filesystem (its "mountpoint"). Note, too, the "RM"field. If this is "1," it indicates that the device is removable. The list is displayed in a tree-like format—use `lsblk -l` to view it as a straightforward list. By default, the drive's size is read in human-readable format (G for gigabytes, M for megabytes, and so on). Use `lsblk -b` to display these figures in bytes, if required. If you have SSDs attached, use the `-D` flag to display support for TRIM (as well as other discarding capabilities). If you want information about your drive's filesystems, type `lsblk -f`, and it also displays the drive's label, and its UUID. The UUID is often used when configuring drives to automatically mount at startup via the "/etc/fstab" file. You can also gain insights into each drive's owner, group, and permissions (listed under "mode") using the `-m` flag. These work in a similar way to the `ls` command, but reveal insights at the top level. You can also sort the drive list by different columns using the `-x` switch—for example, to list drives in size order (smallest drive first), type: `lsblk -x size`.

3 WORKING WITH FDISK

The `fdisk` command is traditionally used to change partition tables, but pair it with the `-l` switch, and



```
nick@nick-pc:~$ lspci -v
00:00.0 Host bridge: Intel Corporation 4th Gen Core Processor DRAM Controller (rev 06)
        Subsystem: ASRock Incorporation Device 0c00
        Flags: bus master, fast devsel, latency 0
        Capabilities: <access denied>
        Kernel driver in use: hsw_uncore

00:01.0 PCI bridge: Intel Corporation Xeon E3-1200 v3/4th Gen Core Processor PCI Express
if 00 [Normal decode])
        Flags: bus master, fast devsel, latency 0, IRQ 25
        Bus: primary=00, secondary=01, subordinate=01, sec-latency=0
        I/O behind bridge: 0000e000-0000efff
        Memory behind bridge: e8000000-f30fffff
        Capabilities: <access denied>
        Kernel driver in use: pcieport

00:14.0 USB controller: Intel Corporation 8 Series/C220 Series Chipset Family USB xHCI (
        Subsystem: ASRock Incorporation Device 8c31
        Flags: bus master, medium devsel, latency 0, IRQ 26
        Memory at f3120000 (64-bit, non-prefetchable) [size=64K]
        Capabilities: <access denied>
        Kernel driver in use: xhci_hcd

00:16.0 Communication controller: Intel Corporation 8 Series/C220 Series Chipset Family
        Subsystem: ASRock Incorporation Device 8c3a
        Flags: bus master, fast devsel, latency 0, IRQ 29
        Memory at f313c000 (64-bit, non-prefetchable) [size=16]
        Capabilities: <access denied>
        Kernel driver in use: mei_me

00:19.0 Ethernet controller: Intel Corporation Ethernet Connection I217-V (rev 04)
        Subsystem: ASRock Incorporation Device 153b
        Flags: bus master, fast devsel, latency 0, IRQ 27
```

it can also display more detailed information about a particular drive. You can use it in conjunction with a drive's identifier (`/dev/sda` for an entire disk, `/dev/sda1` for a partition)—for example, `sudo fdisk -l /dev/sda`.

» This lists the device identifier, its start and end points on the disk (or partition), the number of sectors it has, and its size, plus—a crucial piece of information—the partition type. This is quite descriptive, helping you identify which partitions are which (and particularly useful when examining a dual-boot setup involving Windows partitions).

» Partitions are listed in the order they were created, not their physical position on the drive—look for the "partition table entries are not in disk order" message if this is the case. Examine the "Start" and "End" columns carefully to work out where each partition physically resides on the disk

4 OTHER DEVICES

Two further commands—`lspci` and `lsusb`—provide you with detailed information about other hardware devices. The `lspci` command focusses on your internal hardware, while `lsusb` looks at the peripherals connected to (wait for it) your PC's USB ports.

» Both work in a similar way. On its own, the command lists each connected device—which bus it's on, its device number, and ID, plus some descriptive information (typically the manufacturer and model) to help you identify which is which. Add the `-v` switch for a more detailed view [**Image B**], and don't forget to invoke them using `sudo` to ensure you have full access to all connected hardware.

» Of the two commands, `lspci` produces less information in verbose mode—`sudo lspci -v` will list each device by type and name, then list some extra details, including the device's various capabilities and, rather usefully, which kernel driver it's using. Type `lsusb -v`, however, and you'll be assailed by pages and pages of detailed information about each detected device. Navigating this by hand is excruciating, so we recommend that you start by identifying the USB device you want to check in more detail using `sudo lsusb`.

» Make a note of its bus number and device number, then type the following command: `sudo lsusb -D /dev/bus/usb/00x/00y`. Replace `00x` with your target device's bus number, and `00y` with its device number. This will limit the output to the selected device only.

5 INTERPRET BIOS INFORMATION

One final tool that's worth considering for learning more about your hardware is the dmidecode utility, which takes the information listed in your PC's BIOS, and presents it in a more user-friendly format. What's particularly useful about this tool is that it can glean information from your PC's motherboard, such as the maximum amount of supported memory, or the fastest processor it can handle. It's best used in conjunction with the `-t` switch, which enables you to focus the dmidecode tool on a specific part of your system's hardware—for example, `sudo dmidecode -t bios`.

6 MORE OPTIONS

The BIOS option reveals key information about your motherboard, including what capabilities it supports (including UEFI, USB legacy, and ACPI), plus the current BIOS version, including its release date. Other supported keywords include "baseboard" for identifying your motherboard make, model, and serial number, "processor" (check the "Upgrade" field to see what kind of socket it's plugged into), "memory," and "chassis."

» Note that the DMI tables that contain this BIOS-related information aren't always accurate, so while dmidecode is a potentially useful resource, don't be shocked if certain things don't stack up (it incorrectly reported only half of our RAM, for example). Treat it with due care, and it adds another layer to your system information armory.

GET DRIVER INFORMATION

Most hardware issues can usually be traced to drivers, and Linux is no exception. We've seen how the `lspci -v` command can reveal which driver (or module) is linked to which device. Another tool for displaying these modules is `lsmod`, which displays a comprehensive list of all modules that are currently in use. The "Used by" column lists which hardware devices each module is linked to—multiple entries are common, because some drivers come in multiple parts (your graphics card requires drivers for the kernel and X server, for example).

Armed with both `lspci -v` and `lsmod`, you can identify which particular module is being used by a specific hardware device. Once you have the module name, type the following to learn more about it: `modinfo <module>`.

Replace `<module>` with the name listed under `lsmod` (or "kernel driver in use" if you're using `lspci`). This displays information about the driver filename, its version, and license. Other useful fields include author and description, plus version number. One likely exception to this rule is your graphics driver if you've installed a proprietary one. If `modinfo` returns an "Error not found" message, the listed module is an alias—to find the correct module name, type `sudo modprobe --resolve-alias <module>`, then use the result with `modinfo`, which should now work correctly.

BUILD IT

ZAK STOREY, STAFF WRITER

Everyman's Gaming Machine

Maximum PC's ideal mid-range system, designed to get you the best possible 1440p experience

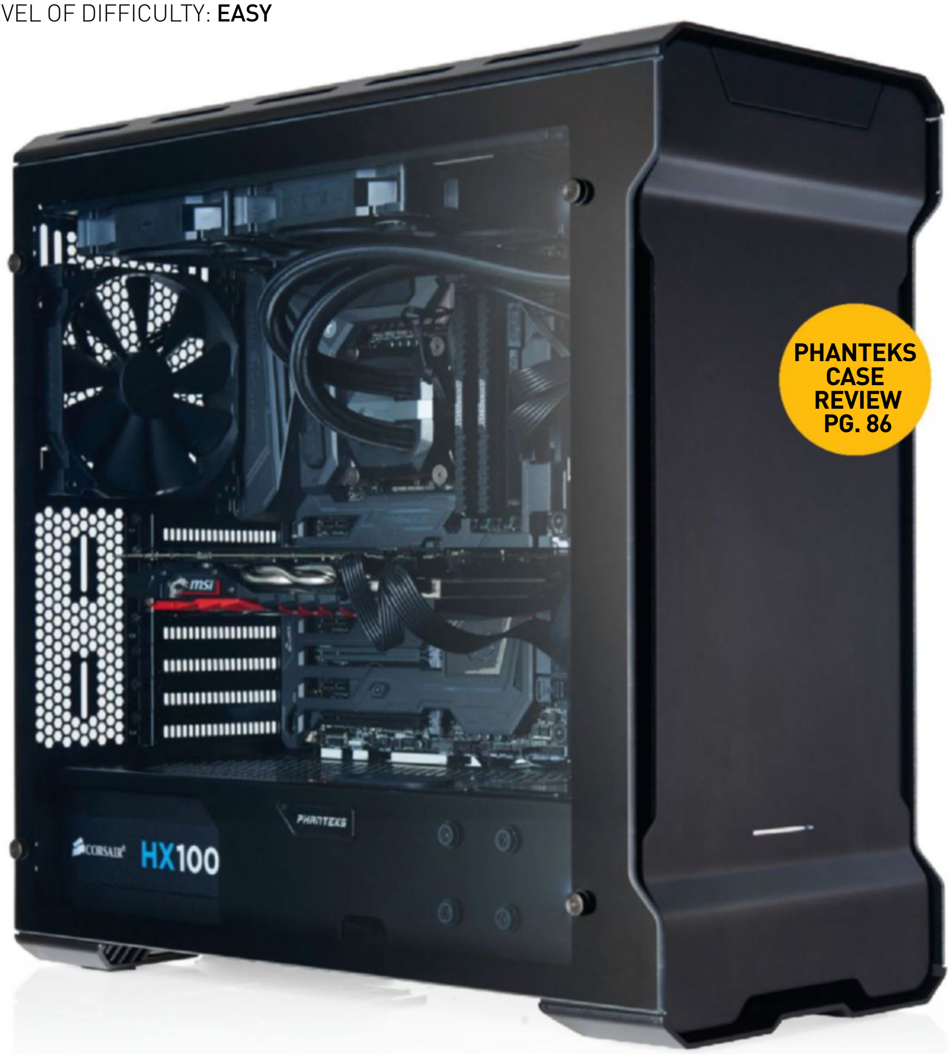
LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WHAT GOT YOU into PCs in the first place? Can you remember? For many of us here at *Maximum PC,* it was gaming. As much as we are all professionals here in the office, utilizing a wide-ranging cornucopia of software in our lives, ultimately it was controlling a plethora of pixelated characters over the years that drew us into a world of higher frame rates, customization, and the best experience possible on a desktop. And that's exactly what this build is all about. Getting back to our roots, piecing together a rig that is centered around a respectable GPU and a gaming workhorse of a CPU.

For the previous three generations of Nvidia GPUs, the premium best-value option from team green has centered around the x70 series of cards. Whether that's the GTX 770, 970, or now the 1070, these graphical processors have always pushed their respective target resolutions to the very pinnacle of frame rate success. Then, of course, there's your choice of processor. The general rule of thumb has been that unless you're making money of out of Hyper-Threading, you simply don't need it. The Core i5 processors have valiantly held aloft the heads of many a talented gamer, those looking again for the best-value premium processor at exactly the right price.



PHANTEKS CASE REVIEW PG. 86

THE GAMER'S DREAM

LET'S CUT TO THE CHASE. This little beastie of ours houses the aftermarket MSI GeForce GTX 1070 Gaming X, overclocked at stock to provide just a touch extra boost clock—far quieter, cooler, and gamier than its Founder's Edition compatriot. On top of that, we've coupled it with Intel's Core i5-6600K, clocked at a lovely 4.4GHz. The legendary quad-core i5 series processors have been at the heart of many a gamer's rig since the launch of Sandy Bridge, way back when, and not a lot's changed. With an exceptional overclocking range, and strong single-core performance, is it any wonder that these are still the gamer's processors of choice? To round all that out, we went with an Asus Maximus VIII Formula motherboard, 16GB of Crucial Ballistix Elite DDR4 @ 2,666MT/s, a Kingston HyperX Predator 480GB PCIe SSD for the OS, plus crucial games and programs, and an additional 960GB of SSD storage in the form of the Crucial BX200. All sitting snugly inside the Phanteks Enthoo Evolv ATX Black tempered glass chassis, which is an absolute dream to work in—roomy and flexible.

There are a few little extras—this time around, we opted to stay with the stock Phanteks fans in the roof and rear of the chassis, still utilizing two Noctua NF-F12 iPPCs for the mighty Corsair Hydro H100i V2.

INGREDIENTS

PART		STREET PRICE
Case	Phanteks Enthoo Evolv ATX Glass	$190
Motherboard	Asus Maximus VIII Formula	$348
CPU	Intel Core i5-6600K @ 4.4GHz	$220
Memory	Crucial Ballistix Elite 16GB (2x 8GB) @ 2,666MT/s	$75
GPU	MSI GeForce GTX 1070 Gaming X	$469
PSU	Corsair HX1000i	$185
Storage 1	Kingston Predator 480GB M.2 PCIe SSD	$300
Storage 2	Crucial BX200 960GB	$240
Cooling	Corsair Hydro H100i V2 plus 2x Noctua NF-F12 iPPC 120mm 2,000rpm fans	$141
Total		$2,168

1

SMUDGES, SMUDGES EVERYWHERE

WE ABSOLUTELY LOVE this chassis here at *Maximum PC*. What Phanteks managed to achieve with the Evolv ATX was simply incredible, especially for those wanting to build a clean, good-looking system with an AIO cooler. The room to move and the quality of the aluminum panels is simply amazing. One thing to bear in mind, however, if you do opt to get the tempered glass version we've featured here, is that those glass panels will smudge. We don't want to put you off; it's just a warning—this baby will require a ton of spit and polish to get it into shape after you're done. It's almost worth wearing gloves, just to avoid getting your grubby fingermarks on that panel. The aluminum panels do stain a bit, too, but it's nothing a little isopropyl alcohol or window cleaner won't get rid of.

2

HIDDEN PCIE SSD

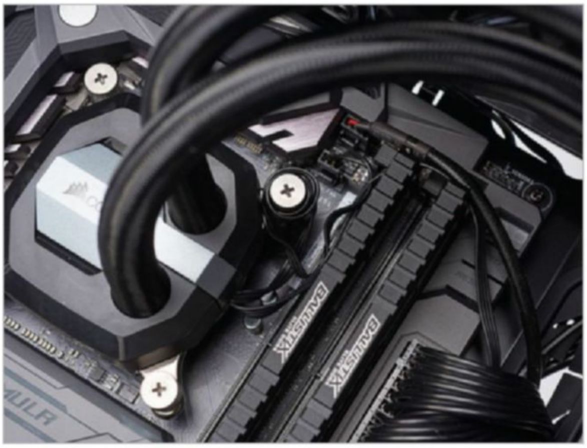
YOU SIMPLY CAN'T BEAT PCIe SSDs. Even the ones at the cheaper end of the spectrum—such as this 480GB HyperX Predator drive—easily outclass even the most hardy of SATA-based SSDs. So, what's the problem? Well, they're hardly the cleanest-looking components. Even Samsung's ever-popular SM951 editions tend to house a green PCB, and despite the black styling of the Predator, and the likes of the new 950 Pros that have recently been released, they're just a little too garish for those looking to build a super-clean system. Say hello to the Maximus VIII Formula's secret weapon, then. A simple, small Phillips screw and a quick yank later—wham! Super-stealthy, hidden M.2 storage under the Formula's Thermal Armor. The word "classy" doesn't quite cut it.

PREDATOR
HYPERX

3

CPU COOLER CABLING

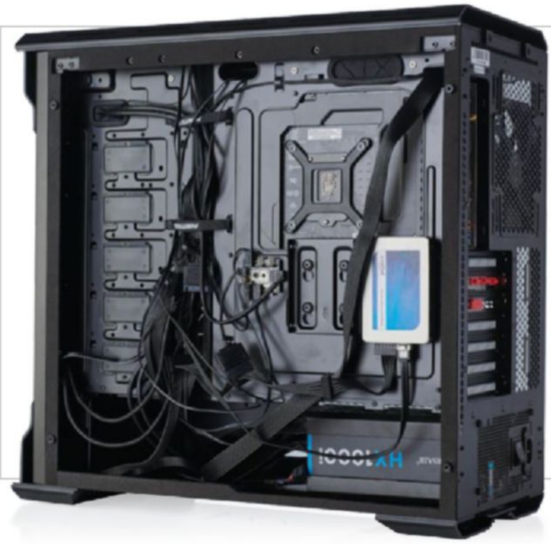
THERE ARE USUALLY two ways to get around messy CPU block cables stemming from those mighty AIOs. Either you luck out with your case/motherboard combo, and can stretch them far enough out the way, or you can tie them up into a little nice loop. Unfortunately, that didn't work for us here, and it ruined our style a little. So, to compromise, instead of wrapping the cables around in a loop as usual, poking out from the sides of the DDR4, we opted to actually wrap them around one of the Hydro's mounting thumbscrews. Is it perfect? No, but it's a lot better than it was.



4

CABLE MANAGEMENT NEEDED

THERE'S A COUPLE OF NIFTY features that the Evolv ATX employs to help keep your cables tidy round the back of the chassis. Those Velcro straps are godsends, and mounting SSDs on the rear of the motherboard tray is a stroke of genius. Couple that with a simple fan hub controlling up to eight fans, and we're on to a winner. Only problem? Well, there's that tempered glass to deal with yet again. Although it's smoked, you can see through it, so your cable management will certainly need to be on point to ensure your rig looks as respectable round the back as it does at the front.



5

POSITIVE PRESSURE

WE CAN'T EMPHASIZE this enough. Positive pressure, positive pressure, positive pressure. Trust us—you'll thank us later. Having a positive pressure fan setup improves internal case temperatures, and helps reduce the amount of dust build-up inside your chassis, meaning it's a lot easier to clean. Thanks to the majority of our fans blowing air into our system, sucking cool air in through dust filters, any air inside the chassis is exhausted and pushed out of the unfiltered areas and gaps, stopping dust from entering your chassis when the system is running. Neat, huh?

6

INSTALLING THAT MIGHTY GPU

WARNING: This is not how you install a GPU; this is how you take a photo of installing a GPU. It turns out, that's quite difficult to make look good. Ensure you remove your PCIe cover on the bottom of the card, remove the two screws holding the PCIe brackets in place, and gently slot your card into the PCIe slot. Then use the same screws to tighten the GPU down, plug in your eight-pin and six-pin power, and voila—you're all done and ready to game. It's rare to have any problems when it comes to installing GPUs; however, some of the heavier cards—Zotac's Arctic Storm comes to mind—might come with a reinforcing bracket or pole to ensure the weight of the card doesn't put too much strain on the motherboard, and also to avoid GPU sag.

MSI
GTX 1070
REVIEW
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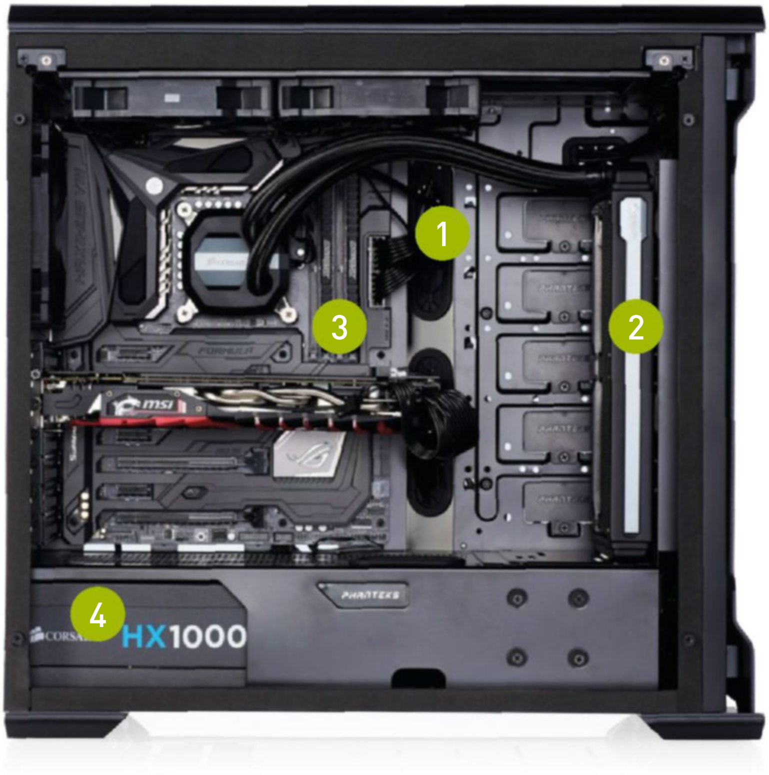

1 **If we've said it once, we've said it a thousand times: custom cable kits always make a build pop. We'd have loved to have gone with some custom sleeved cables here. If you haven't got the time, there are plenty of modders out there happy to sell you custom sleeved cables. Even Corsair sells them; alas, without cable combs to keep them tidy.**

2 **Radiator orientation is something that you'll constantly get criticized for. Apart from fan orientation and pressure systems, it's one of the most controversial and heavily debated topics on the Internet. In our experience, however, whether you mount in the roof or the front of the chassis really doesn't make a huge difference, especially in a positive system.**

3 **One problem we had with this particular combination of motherboard and case was with the USB 3.0 front panel connectors (just south of the 24-pin ATX power). As you may have noticed, there's no grommet directly opposite it, and because the USB 3.0 front panel has such a stiff cable, we opted to not plug it in at all. A little inconvenient, but not the end of the world.**

4 **We'll admit that the 1,000W PSU is overkill for this build. Especially considering how quiet even Corsair's RX series power supplies are. A Corsair RM650 would've been plenty, even with those mighty overclocks chunking away at the Intel Core i5-6600K and GTX 1070.**

THE GAMER'S POWERHOUSE

THE TRUE BEAUTY of personal computing lies within the community. Shocking? Think about it for a moment. Ask yourself, what is a "good" PC? It's no easy question. After all, you could drop $20,000 on parts, and piece together a masterfully crafted silicon monster capable of rendering the world asunder with its mighty 48-thread processors. But is that a "good" PC? To us at *Maximum PC,* maybe. But to the 12-year-old setting his sights on his first gaming system, or the sound engineer looking for a new recording studio setup, or the pensioner after an HTPC for the den? Probably not.

And that's what's so fantastic about our community—there's never a right answer when it comes to component selection. It depends on what you need the system to do, what games you play, what programs you use, what resolution you run at.

With this machine, however, in our eyes, it's one of the best mid-to-high-end gaming PCs you could set your sights on. There's a few things you could change to make it cheaper, or increase cost and performance, but for 1080p and 1440p, it's nigh-on perfect. It's crisp and clean, the Phanteks Enthoo Evolv ATX chassis was fantastic to work inside; it did have a habit of picking up fingerprints, but that's par for the course with glass and aluminum. Cable management was excellent, and the extra mounting points for hiding SSDs were neat.

As far as the system goes, it does lean a little on the extreme side of component selection. It would be possible to achieve the same performance with, say, an air cooler, or a lower specced card. MSI's Gaming X variant of the GTX 1070 is around $20 more than even the Founder's Edition, but you'll still be able to get a GTX 1070 with a reference PCB and a dual-cooler for around $430 once stock makes it to market. Couple that with a 650/750W power supply, and potentially a smaller PCIe SSD, and you're on to a winner real fast.

As for performance, we were impressed with the Intel Core i5-6600K. Although we didn't push it to its absolute limit, that impressive overclock, up to 4.4GHz, was more than enough to keep the frame rate gods happy. And it wasn't too far behind the Core i7 in our zero-point. Pretty nifty. The big winner here was the GeForce GTX 1070. What a card! For value for money, it's the king of cool right now. Again, we didn't overclock it, but it's possible to get 2,000MHz-plus on this beauty, for some impressive gains on the average and minimum frame rate front. The HyperX Predator let us down a bit, with read and write speeds comparable only to that of a two-disk RAID 0 setup. That aside, we ended up with one nippy system, more than capable of some thoroughly enjoyable gaming at 1440p.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	727 (-26%)
Cinebench R15 Single Thread	196	189 (-3%)
TechARP's x264 HD 5.0.1 (fps)	21.93	17.95 (-18%)
PC Mark 8 Creative	7,675	8,937 (16%)
Rise of the Tomb Raider	41	57 (39%)
Far Cry Primal	76	93 (22%)
The Division	78	87 (12%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM.
All games are tested at 1080p on max settings, with HD texture packages installed.

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TESTED. REVIEWED. VERDICTIZED.

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MSI GeForce GTX 1070 Gaming X 8G

The king of value—sort of

The only thing this is missing is racing stripes.

USED IN BUILD IT PG. 66

LET'S FACE FACTS: The GTX 970, despite its shortcomings, was by far the best card to buy last generation. The GTX 980 Ti may have been more powerful, and the GTX 950 an incredible entry point, but if you were looking for the best possible bang for buck, as far as frame rate performance at 1080p was concerned, the 970 was where it was at. The 1070, then, its Pascal 16nm successor, has a lot to live up to.

With 1,920 CUDA cores, 120 texture units, 64 ROPs, and 8GB GDDR5 VRAM on a 256-bit bus, it's off to a good start. Although not as powerful as its GTX 1080 cousin (640 fewer CUDA cores and no GDDR5X), the GTX 1070 isn't one to hang around.

When you break it down, there are three base SKUs available. First you have the Founder's Edition, featuring a fancy metallic shroud and bumped-up early access fee. Then there are the true reference edition cards from the aftermarket partners, featuring blower-style coolers, as well. And finally we have the super-top-end elite cards, such as the Asus Strix or MSI Gaming X, coming with custom PCBs, better power phase design, and generally some fancy combination of RGB lighting and super-cooling technology.

For this review, we decided to skip Nvidia's Founder's Edition, and opt for something a little more premium. MSI was gracious enough to offer up its Gaming X card to the bench, and we dove right in. At stock or "silent mode," MSI's Gaming X variant performs admirably, almost identically to our reference cooler, with just a few differences. Thanks to the new TORX 2.0 fan technology that MSI has introduced with this edition of its legendary Twin Frozr cooler, the card remains incredibly cool. Coupled with 0dB fan technology, which doesn't kick in until the card is running at more than 60 C, you're in for some exceptionally quiet, cool gaming, especially on less demanding titles, such as *Hearthstone, DOTA*, and their ilk.

Speaking of modes, this is all centered around MSI's new Gaming App. Designed to work alongside Afterburner and Kombustor, this little executable gives you access to both LED management and preset overclock profiles. The "gaming mode" is the next one up, featuring a meager overclock of 88MHz on the GPU clock. If we're honest, we're not sure why this exists, as you also have access to the OC mode, taking the max boost clock all the way up from the stock 1,683MHz to 1,797MHz, a full 114MHz. It doesn't sound much, but it should net you at least two or three fps extra in most intensive AAA titles.

However, let's be honest—that's a little mediocre. Pascal has essentially been nothing short of an architecture shrink, resembling Maxwell in all but transistor size, and sure enough, it remains an exceptional overclocker, as far as architectures go. In our testing, we managed to really ramp the overclock up, achieving a final boost clock of 2,073MHz, almost a full 400MHz higher than stock. In game (*Far Cry Primal* at 1440p), we saw this increase both our average and minimum frame rates by four or five frames per second. Temperatures remained steady at 70 C under load—alas, we couldn't push it any harder than this.

X MARKS THE SPOT

So, is the GTX 1070 the king of cool? Undoubtedly, it's a powerful card; it performs well at 1440p, providing high frame rates in what we like to call your everyday games, but it just feels as though it needs to be a touch cheaper to really warrant our prestigious and highly coveted Kick Ass award. As far as MSI's Gaming X variant goes, it's a solid advancement and nice redesign on the last iteration of Twin Frozr. Our only gripe stems from the inclusion of RGB lighting on a card that is predominantly still red and black. Otherwise, it clocks like a champ, keeps itself incredibly cool, and is one of the quietest cards we've ever used. That aside, the armored black and white variant, coming in a little cheaper, and with the same overclock potential, does have our attention. If anything, that little beauty has to be the king of value right now, as far as the GTX 1070 is concerned. **–ZAK STOREY**

VERDICT

9

MSI GeForce GTX 1070 Gaming X 8G

➕ **X GAMES** Impeccable 1440p performance; great cooling solution; innovative new design; 0dB fan tech; low power draw.

➖ **XTRA CREDIT** Pricey; RGB LEDs on red card.

$469, www.msi.com

BENCHMARKS

	MSI GeForce GTX 1070 Gaming X in OC Mode	Nvidia GeForce GTX 980	Nvidia GeForce GTX 970
Fire Strike @ 1080p	**15,440**	11,338	9,525
Fire Strike Extreme @ 1440p	**8,221**	5,822	4,915
Fire Strike Ultra @ 4K	**4,499**	3,132	2,545
Total War: Attila	**23/36**	14/23	11/21
Far Cry Primal	**55/65**	38/45	27/31
The Division	**47/63**	23/53	14/37
Rise of the Tomb Raider	**14/35**	8/24	5/20
Ashes of the Singularity	**61/73**	26/30	12/20

Best scores are in bold. Game results are minimum and average fps at 1440p. Our test bed consists of a Core i7-6700K and 16GB of Kingston Savage DDR4 @ 2,400MT/s on an MSI Z170A Gaming M7.

SPECIFICATIONS

GPU	Pascal
Lithography	16nm FinFET
Transistor Count	7.2 billion
CUDA Cores	1,920
Texture Units	120
ROPs	64
Core/Boost Clock	1,607MHz/1,797MHz
Memory Capacity and Type	8GB GDDR5
Memory Speed	8GHz
Memory Bus	256-bit
TDP	150W
Display Connectors	DisplayPort 1.4, HDMI 2.0b

Digital Storm Aventum 3

A big, badass, blue box

WHEN WE FIRST TALKED to Digital Storm about its new Aventum 3 desktop, we were excited to see what sort of performance the company's flagship PC could offer. Unfortunately, we were forced to wait. The original spec called for GTX Titan X video cards, but Digital Storm held off to put a pair of the new GeForce GTX 1080 cards in place of the Titans. We have to say, it was worth the wait.

The Aventum 3 is a massive machine. It's big enough that the term "desktop" is something of a misnomer. This PC will most likely make its home on your floor, unless you have a very sturdy, large desk, and a friend with a strong back to help you lift it. And there's a reason it's heavy: This PC has lots of cooling running every which way, complete with custom acrylic interchanges, and EKWB water blocks for the CPU and GPUs.

The machine sports Intel's new enthusiast flagship CPU, the 10-core Core i7-6950X. With a stock base clock of 3GHz and a turbo of 4GHz, the 6950X in this PC came clocked at 4.3GHz. That's a respectable overclock, and is right in line with what we've found to be stable in our own testing. It's not as high an overclock as we've seen with the Haswell-E i7-5960X (which can get to 4.5GHz from a turbo of 3.5GHz), but Intel's "Extreme Edition" CPUs are really more about the cores, PCIe lanes, and cache than the clocks. Speaking of cores and cache, the 6950X sports 10 cores with Hyper-Threading, for a total of 20 threads. The CPU has 25MB of cache, which preserves the allotment of 2.5MB per core that we've seen on the 5960X (which has eight cores and 20MB of cache).

WHEN ONE GPU ISN'T ENOUGH

For pixel-pushing, the Aventum 3 doesn't pull any punches. This monster has two GTX 1080 Founders Edition graphics cards fitted with EK waterblocks. The pair is joined together with Nvidia's high-bandwidth (HB) SLI bridge. This makes use of both the SLI connectors on each card (vanilla SLI only uses one). This is part of the reason Nvidia recommends that builders limit SLI to two-way. (You can use three-way SLI, but you have to contact Nvidia for a code to unlock the cards.) Digital Storm had to remove the plastic cover for the SLI bridge, as it won't fit with EK's waterblocks. That's no big deal, and the hit to aesthetics is minimal.

Digital Storm took these badass components and mounted them on an Asus X99 Deluxe II mobo, along with 32GB of Corsair's Vengeance LPX DDR4-3000 RAM. Storage needs are met by a 512GB Samsung 950 Pro and a 6TB Seagate Barracuda. The rig is topped off with beautifully clean cable management. There are also pre-wired connections for 3.5-inch HDDs, making hard drive installation as plug-'n'-play as possible. The hard tubing of the water-cooling loop is gorgeous. The white coolant reminds us of Bishop's blood from *Aliens*.

The 1080s delivered in gaming, and made the Aventum 3 a shining example of what Nvidia's new GPU can do. In our 1080p tests, the Aventum 3 barely broke a sweat, scoring 26,853 points in Fire Strike. For games, the rig pumped out 116.7fps overall in *Rise of the Tomb Raider* (154.48fps in Peak, 105.15 in Syria, and 88.67 in Geo), with max settings at 1080p. In *Far Cry Primal*, it managed 86fps, and Brooklyn was rendered at 163.3fps in *The Division*.

Not satisfied with the 1080p results, we tested higher resolutions as well. In Fire Strike Ultra, the rig scored 10,467. Lara Croft graced our screen at 87.1fps at 1440p, 43.25fps at 4K (2160p). While frame rates did drop during the test, they didn't drop below 30fps in Fraps during the 4K test.

When it came to computing, the Aventum 3 crushed the rigs we've tested before. With 10 cores and 20 threads, the PC managed 10,303 in PCMark 8, and nearly 2,200 in Cinebench 15. In x264—where more threads are always better—the Aventum 3 pushed a whopping 45.87fps. Yowza!

When it comes down to it, the Aventum 3 is one kick-ass rig. But as the rig we tested comes with a sticker price of $8,573, it had better perform. And perform it did. Besides the fact you'll have to rearrange some furniture and use a hand truck to move it, we can't find much to complain about. Bigger isn't always better, but in this case, it absolutely is. –**ALEX CAMPBELL**

VERDICT
9
K!CK ASS

Digital Storm Aventum 3

+ BLUE STEEL Top-tier performance; gorgeous water-cooling loop; great cable management; solid case design.

− FEELING BLUE Very heavy; pricey.

$8,573 (as configured), www.digitalstorm.com

BENCHMARKS

	ZERO-POINT	
Cinebench 15	987	2,190 (122%)
x264 HD 5.0 (fps)	21.93	45.87 (109%)
PCMark 8 Creative	7,675	10,303 (34.2%)
CrystalDiskMark 4K Read	54.85	657 (1,099%)
CrystalDiskMark 4K Write	171	420 (146%)
Far Cry Primal (fps)	76	86 (13.2%)
The Division (fps)	78	163 (109%)
Rise of the Tomb Raider (fps)	41	117 (185%)
3DMark Fire Strike	15,026	26,853 (78.7%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point has a Core i7-6700K overclocked to 4.6GHz, an XFX Radeon R9 Fury X, 32GB of Kingston HyperX Savage DDR4-2400, and a 256GB Samsung 950 Pro, mounted on an Asus Z170i Pro Gaming mobo.

SPECIFICATIONS

Processor	Intel Core i7-6950X @ 4.3GHz
Graphics	2x GeForce GTX 1080 FE
RAM	32GB Corsair Vengeance LPX DDR4 @ 3,000MT/s
Motherboard	Asus X99 Deluxe II
Primary Storage	512GB Samsung 950 Pro
Additional Storage	6TB Seagate Barracuda 7,200rpm HDD
Cooling Solution	EKWB water blocks; Digital Storm Hydrolux Pro system
PSU	Corsair AX1500i
Case	Bespoke chassis
Warranty	3 year limited (3 year labor and 1 year part replacement)

The Aventum 3 dishes out a double dose of graphics power.

All it needs is some side pipes, and we'll be all set.

SEE TECH PORN PG. 48

Asus ROG GX700VO

By Zeus's beard, what have you done Asus?

MOBILE GAMING has always had a certain stigma. It's more expensive than a console, yet insurmountably inferior to the towering powerhouse of a desktop PC. Take the GTX 970M as an example. It comes with 1,280 CUDA cores, 384 fewer than its desktop sibling, a lower base clock, 192-bit memory bus as opposed to 256-bit, and half the memory bandwidth of its counterpart. Unfortunately, the story doesn't stop at GPUs, either, because even though Intel continues to push the boundary in terms of performance per watt and economic power savings, its mobile processors suffer the same setbacks.

So, why on earth would you buy one? Usually, there's just one reason: Convenience. Perhaps you travel a lot, don't have the space for a full-sized desktop, or are heading to varsity? Then a gaming laptop may be your only solution. Fortunately, last year Nvidia announced the launch of its full-fledged mobile gaming GTX 980. Designed specifically for use in notebooks, this chip was, in essence, identical to its desktop counterpart. The same number of CUDA cores, texture units, and ROPs, and it even managed to retain the 256-bit memory bus. The only difference? A slight reduction in clock speed, to allow for the increased thermal output of a desktop processor.

On its own, the mobile GTX 980 would make any gaming laptop an absolute monster of absurdity, especially at 1080p. However, couple it with Intel's latest overclockable Core i7-6820HK, and you're starting to see performance similar to the mid-range desktops we're used to—but in a far smaller form factor. However, Asus didn't think that was good enough. After all, if you're forking out so much money on these components, why on earth would you want an underclocked GPU and CPU? Thus, the world's first liquid-cooled gaming laptop, the GX700VO, with its phenomenal water-cooling dock, was born.

IN THE DOCK

How does this contraption work? Well, there are two parts: the dock, with a rather substantial power brick, and the laptop itself. While your dock is plugged in, you simply slot the laptop on to the top of its mounting points, and press the mechanical, metallic lever down on top. It then locks into place, to the sound of a large beep, indicating that the dock is secure, and the coolant system is activated. The GX700 itself detects whether it's securely plugged into the dock, and activates the GPU and CPU overclocks.

We do have to address old Nelly in the room—this laptop costs $5,000. Is there any way to justify that? Probably not, but it does come with some nifty features. Our variant, the VO, came with an Intel Core i7-6820HK (2.7GHz stock, 4.0GHz docked), 64GB of DDR4 SDRAM (2,133MHz stock, 2,800MHz docked), two RAID0 configurations, housing a total of 1TB of storage (one being a PCIe M.2 RAID0 setup), a G-Sync enabled 60Hz 17-inch 1080p IPS screen, a full-sized keyboard, and what can only be described as a monstrously sturdy flight case, for those moments when you need to escape the country, laptop, dock, and all.

Performance-wise, we were a tad cruel, and compared it to our zero-point desktop. After all, desktop performance is the name of the game, correct? Cinebench Single and Multi-Threaded performance shone, achieving 663 points on the multi-core test, sans overclock—just a touch behind a well overclocked i5-6600K. In gaming, average frame rates remained well above 60fps in both *Far Cry* and *The Division*, with 3DMark achieving an impressive score, exceedingly close to our GTX 980.

Has Asus achieved what it set out to do? Yes, but at what price? This machine, although incredible in its conception, is nothing more than an exercise in engineering. This is strictly for those with bottomless wallets, and the desire to have the very best portable gaming experience possible, and an adequate experience at home. To put this into perspective, a full desktop equivalent, including monitor, peripherals, and speakers, comes to about $3,300—that's $1,700 less than the GX700. We'll say no more. **–ZAK STOREY**

VERDICT 8

Asus ROG GX700VO-GC009T

+ ICE COOL Impressive engineering success; desktop-level graphical performance; speedy RAID0 storage; feature-packed.

− LUKEWARM $1,700 price difference; over-engineered; not particularly portable.

$5,000, www.asus.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15	987	663 (-32%)
x264 HD 5.0 (fps)	21.93	19.44 (-11%)
PCMark 8 Creative	7,675	5,578 (-27%)
CrystalDiskMark 4K Read	54.85	50.25 (-8%)
CrystalDiskMark 4K Write	171	142 (-17%)
Far Cry Primal (fps)	76	64 (-16%)
The Division (fps)	78	60 (-23%)
Rise of the Tomb Raider (fps)	41	42 (2%)
3DMark Fire Strike	15,026	11,123 (-25%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point has a Core i7-6700K overclocked to 4.6GHz, an XFX Radeon R9 Fury X, 32GB of Kingston HyperX Savage DDR4-2400, and a 256GB Samsung 950 Pro, mounted on an Asus Z170i Pro Gaming mobo.

SPECIFICATIONS

Processor	Intel Core i7-6820HK @ 2.7GHz
Graphics	Nvidia GeForce GTX 980
RAM	64GB DDR4 @ 2,133MT/s
Chipset	CM236 Express
Display Type	17.3-inch 1080p IPS
Primary Storage	512GB RAID0 PCIe
Additional Storage	512GB RAID0 SSD
Connectivity	3x USB 3.0, 2x USB 3.1, Thunderbolt, HDMI, Mini DisplayPort, SD card reader, Ethernet, 3.5mm audio
Dimensions	16.9 x 12.2 x 1.3 inches (without dock)
Weight	8lb, 10oz

STRIX
REPUBLIC OF GAMERS
STRIX X99 GAMING
ASUS
SUPREMEFX

It comes in pink. Pink!

Asus ROG Strix X99 Gaming

Asus brings entry-level X99 gaming to the masses

IF BROADWELL-E HAS shown us anything, it's that Intel is really starting to champion HEDT as being an accessible platform for gamers. And it's with good reason. For the longest time, the mainstream Intel Core i5s and i7s were the epitome of what we'd consider a good gaming processor. At least, until the launch of Haswell-E. It was a slow transition, but with the introduction of the Intel Core i7-5820K, we began to see an affordable high-end six-core processor available to the masses. And as the gap continued to close between the highest of high-end Skylake processors and the lowest-end X99 chip, it was only a matter of time before the Core i7-6800K was finally placed right in the sights of those looking for a more powerful gaming processor. This is something that Asus is capitalizing on with the launch of its A-II, and now with the ROG Strix X99 Gaming variant, as well—both aimed at those who like a little more pizzazz with their system.

In its overall layout and specifications, the Strix is essentially a reskinned Asus X99 A-II ($250), identical to the one we reviewed last issue. It still comes with support for 128GB of DDR4 up to 3,333MT/s, still has the same number of PCIe slots, still has a single M.2 slot and U.2 connector, and still has those funky LED PCIe lights. Even the fan headers are the same. There has to be something different, though, right? Especially considering the dramatic price jump for the ROG. Well, you lose out on two SATA 6GB/s ports (although, to be fair, if you're using all 10, something's amiss here anyway), but you do gain access to 802.11ac Wi-Fi, with 2x2 dual-band 2.4/5GHz antennas. And there's a slightly improved audio solution, too.

IN THE PINK

Then we come to the aesthetic design decisions. Yep, we're talking RGB LEDs here. You get one little extra strip along the top of the board, under the rear I/O cover. This strip, in combination with the PCIe LEDs, works in conjunction with Asus's Aura software to give a wide variety of different lighting effects. And then there are the stickers. How could we forget the stickers? As you may notice, our board is a lovely shade of pink. As standard, the motherboard comes with orange stickers, but you can swap these out to either green, pink, or a silvery gray, to better color-match the rest of your build. Alas, this swap is a one-time affair, and although they're a thick foil design, they can stain very easily, especially once you've pulled off the clear plastic cover.

As for performance, the Strix X99 is quite impressive. Whether it's down to Asus's tomfoolery with its Enhanced Turbo Ratio settings in the BIOS, or thanks to a rethink and redesign of the overall MOSFETs supporting the overclocks, the Strix Gaming absolutely stomped over our TUF Sabertooth in testing. At stock, it outclassed that long-toothed kitten by 2.5fps in x264, and over 100 points in Cinebench; even overall memory latency was lower. As usual, gaming made little difference, short of the processor struggling to keep up in Fire Strike with the newer board. And as far as overclocking was concerned, we managed to pinch an increase of 100MHz over both the A-II and the TUF Sabertooth ($307), hitting 4.4GHz at 1.35V on our Intel Core i7-6950X.

So, should you buy this board? It depends how much you need that "gamer" feel. It's got the looks and performance to back it up, especially if you intend to run it at stock, but if you're after the best bang for your buck, with the latest and greatest of Intel's HEDT processors, you'd be far better off going with the A-II instead. **–ZAK STOREY**

VERDICT
8

Asus ROG Strix X99 Gaming

+ STRIP POKER Clean design; powerful overclocker; solid performance; customizable; wireless a/c.

− WITH GRANDPA Price hike for ROG name.

$339, www.asus.com

BENCHMARKS

	Asus ROG Strix X99 Gaming	Asus X99 TUF Sabertooth
TechARP x264 V5.0.1	**39.07**	36.43
Cinebench R15	**1,859**	1,711
Memory Bandwidth (SiSoftSan)	**54.21GB/s**	52.36GB/s
AIDA64 Memory Latency	**72.2ns**	73.1ns
CrystalDisk Sequential Read	**550MB/s**	514MB/s
CrystalDisk Sequential Write	**530MB/s**	503MB/s
Power Draw Idle	**67W**	75W
Power Draw Peak	365W	**341W**
Far Cry Primal @ 4K	**42fps**	**42fps**
3DMark Fire Strike Extreme	**9,734**	9,660
Maximum Overclock Achieved	**4.4GHz**	4.3GHz

Best scores are in bold. All benchmarks performed with an Intel Core i7-6950X, 32GB of DDR4 2400 (4x 8GB), GeForce GTX 1080, and a Samsung 850 Evo 500GB.

SPECIFICATIONS

Chipset/Socket	X99/LGA 2011-3
Form Factor	ATX
Memory Support	128GB DDR4 @ 3,333MT/s
M.2/U.2 Support	1x M.2, 1x U.2
SATA Support	8x SATA 6Gb/s, 1x SATA Express
Max PCIe Support	3x PCIe 3.0 x16 (x8/x16/x8)
Rear I/O	4x USB 2.0, 4x USB 3.0, PS2 combi port, BIOS reset, 5.1-channel audio, Wi-Fi a/c

Brilliance
2:33 DEFEND OBJECTIVE A
DEFEND
147 / 200
36%
TMFR
PHILIPS

With 14 million pixels, is 5K really 50 percent better than 4K?

Philips Brilliance 275P4VYKEB

Do you really need 14 million pixels?

IS THERE A POINT at which adding more pixels becomes futile? This question hits home the moment you fire up Philips' new Brilliance 275P. Actually, it's not quite the first thought to cross your mind—that's more likely to be, "Does this thing really need two DisplayPort cables?"

Indeed it does, for the 275P boasts no fewer than 5120x2880 pixels. Yes, that's 5K. Sorry, folks, but your 4K screens suddenly look positively puny. The downside, of course, is that the prevailing DisplayPort 1.2 specification maxes out at 3840x2160 at 60Hz refresh. Driving the Philips' full pixel grid at 60Hz is beyond the means of a single DisplayPort 1.2 interface, which is why you' need two of 'em. That throws up compatibility issues with video cards that only offer a single port, and can make for niggling issues with multi-GPU setups.

But let's assume you have the basic graphics grunt to drive the 275P in 2D desktop mode. What then? Your initial impression will be shock and awe, most likely. This isn't a particularly large display in physical terms, measuring 27 inches in diagonal, but that only adds to the impact of those 14 million pixels. The consequence is a super-tight pixel pitch and razor-sharp images, the likes of which you've probably never seen in a PC monitor.

In fact, the overall spectacle is more akin to a high-density smartphone display. The image is almost seamless, while normal monitors have a very visible pixel grid. It's punchy as hell, too, thanks to a combination of IPS panel technology, a glossy screen coating, and full 10-bit-per-channel color support. This thing has contrast in spades, and the color saturation is off the charts. At a glance, you could be forgiven for thinking its a VA-type panel, that's how rich, vibrant, and saturated it looks.

But thanks to that IPS technology—strictly speaking, it's PLS not IPS, but PLS is essentially a subtype of the broader IPS genre—it's much more accurate than any VA panel. Philips claims 99 percent Adobe RGB and 100 percent sRGB consistency, courtesy of factory calibration. The viewing angles are pretty exceptional, too, if you ignore the reflectivity that's part of the glossy-screen package. The pixel response is also reasonably zappy, and given the roughly $1,400 sticker, you won't be surprised to learn that the stand offers a full range of adjustability.

BROKEN WINDOWS

If that's the good news, here comes the bad. For starters, Windows still doesn't do scaling properly. Bump the built-in scaling option up from 100 percent, and there's brokenness everywhere. A lot of this isn't Microsoft's fault. The fact that most of the web is built up from non-scalable bitmaps is beyond Microsoft's control. Ditto patchy support for high-DPI displays like this across the Windows app ecosystem.

As for gaming, well, running this thing at native resolution in modern games is going to take one hell of a 3D rendering solution. Even Nvidia's latest GTX 1080 will struggle. All of which means the appeal of the Philips Brilliance 275P is awfully narrow. If you are a graphics or video production professional, who uses apps that can make full use of the huge 5K pixel grid, great. But for the rest of us, running this kind of high-DPI display in Windows still presents too many problems. –**JEREMY LAIRD**

VERDICT

8

Philips Brilliance 275P4VYKEB

⊞ **RAZER-EDGED** Searing visual sharpness; huge pixel grid; top panel quality.

⊟ **BLUNT** Windows doesn't scale well; probably too many pixels for gaming.

$1,400, www.usa.philips.com

SPECIFICATIONS

Panel Size	27-inch
Native Resolution	5180x2880
Pixel Density (ppi)	218
Panel Type	PLS, 10-bit
Max Refresh	60Hz
Response Time	8ms
Contrast	1,000:1
Inputs	2x DisplayPort
VESA	100mm x 100mm
Warranty	Three years

Zotac Sonix 480GB

Zotac's hot new NVMe is go for launch. But is it ready...?

AFTER YEARS of SATA-bound stagnation in solid-state storage, something is finally happening. That's thanks to a new generation of drives powered by the lightning-quick PCI Express interface, and bolstered by the NVMe control protocol.

But when it comes to SSDs, even the fastest drives can be undone by patchy product development. Enter the exciting new Zotac Sonix. Like Intel's 750 Series SSD, the Sonix is a pure PCI Express card that slips into a 4x PCIe slot, so doesn't require an M.2 port on your motherboard.

The Sonix is based on the new cutting-edge Phison PS5007-E7 controller, with a quad-core processor, and support for the aforementioned NVMe protocol. The Sonix runs over a quad-lane PCIe connection, and packs 512MB of DDR3 DRAM cache. The upshot of all that involves some pretty staggering performance claims.

Peak sequential throughput is pegged at 2.6GB/s for reads, and 1.3GB/s for writes, while the read and write IOPS come in at 350,000 and 250,000 respectively. In our best *Quake III* voice, that's impressive. But reports indicate that Zotac launched the Sonix with a release candidate of Phison's controller firmware for the E7 chipset, rather than waiting for the final production build. Hold that thought.

UP TO SPEED

Initial benchmark impressions are awesome. The Sonix vaporizes ATTO sequential bandwidth tests, notching up 3.1GB/s reads and 2.3GB/s writes. From there, things get complicated. Our first few runs of the AS SSD benchmark spat out results that looked all wrong, with sequentials in the hundreds of MB, and 4K writes way down at sub-10MB/s. Not good. A spot of research suggested turning off write cache buffering, and checking that box did the trick, with sequentials of around 2.2GB/s and 1.3GB/s. The 4K randoms look competitive with this class of drive, too, at 50MB/s for reads and 153MB/s for writes. Our real-world tests look decent, as well, if not quite best-in-class. One minute and three seconds for our 30GB internal file copy test is a fair distance behind the 43 seconds achieved by the fastest drive we've ever tested, namely the Samsung 950 Pro.

All of which makes the Sonix a tempting option. The new Phison controller clearly has some serious horsepower, but we have concerns about Zotac's competence in this part of the market. Zotac doesn't make the controller chip, and it doesn't code the firmware. Being first out the door with the new Phison NVMe chipset is no doubt attractive for marketing purposes, but it's not necessarily a good thing for customers.

This an exciting new SSD, and Phison will no doubt mature into a solid controller. It's early days for NVMe, but we'd hold off that Sonix purchase for now, and allow a few firmware updates to cycle through before pulling the trigger. –JEREMY LAIRD

VERDICT 8

Zotac Sonix 480GB

+ **SONIC THE HEDGEHOG** Crazy fast peak throughput; solid all-round performance; cutting-edge tech.

− **SONIC BOOM** Firmware probably needs some polish; toggle to unlock full performance puts data at a small risk.

$382, www.zotac.com

BENCHMARKS

	Zotac Sonix 480GB	Intel 750 1.2TB	Samsung 950 Pro 512GB
AS SSD Sequential Read/Write (MB/s)	**2,211 / 1,299**	2,121 / 1,253	2,028 / 557
CrystalMark Sequential Read/Write (MB/s)	1,512 /1,426	1,298 / 1,271	**2,210 / 1,539**
CrystalMark 4K Read/Write (MB/s)	40 / 203	37 / **326**	**51** / 198
5GB Zip (seconds)	**190**	196	193
30GB Copy (seconds)	63	**42**	43

Best scores are in bold. Our test bench consists of an Intel Core i7-6700K, MSI Z170A Gaming M7, 2x 8GB Crucial Ballistix Elite DDR4-2666, and a GeForce GTX 980.

SPECIFICATIONS

Capacity	480GB
Interface	PCI Express 4x
Control Protocol	NVMe
Controller	Phison PS5007-E7
NAND Type	MLC
Sequential Read	2.6GB/s
Sequential Write	1.3GB/s
Read IOPS	2.6GB/s
Write IOPS	1.3GB/s
Warranty	Three years

Munro Sonic Egg150

Mighty egg-shaped juggernauts

WE WERE SO IMPRESSED by the MunroSonic Egg100 monitoring system, we just had to take a look at its larger sibling, the Egg150. Designed and built in Britain by legendary sound man Andy Munro, the Eggs are a stunning example of modern acoustic engineering.

In a move away from the industry standard for studio monitors—a pair of rectangular boxes with the amps inside—the Egg150 system comes with an external amplifier, custom-tuned to power two ovoid speakers, each housing a 25mm high-frequency driver and a 165mm woofer. As well as looking awesome, the egg-shaped design allows for a totally resonant-free sound, giving as flat a response as possible.

The Eggs are mounted on moulded rubber nests, which enable you to make minute adjustments to both the vertical and horizontal positioning of the speakers. This is aided by a clever LED aiming device, which ensures you have the Eggs set up so the time-alignment of the drivers is optimum. This is actually an incredibly useful, yet simple, tool to use; a blue LED set above the high frequency driver appears to shine brightest when the speaker is at the perfect angle relative to your seating position. And, boy, does it shine, distractingly so. Fortunately, once you've finished setting up, the LED can be deactivated by a switch on the back of the amplifier.

The amp itself is a large, heavy, 19-inch beast, which can be rack-mounted if necessary. Input options are either balanced XLR or RCA phono, with individual volume knobs for each on the front of the unit. These are nice, weighty controls, with a handy indent at halfway. So much nicer to use than the tiny volume pots on the back of most monitors. The front of the amp also features an input selector, a mid-range boost/cut control, and a headphone socket. The unit acts as a dedicated headphone amplifier, which will bring out the best in any pair of cans you plug in.

TOUCHING BASS

The Egg150 system is an absolute joy to use. The depth and clarity of the sound produced is breathtaking. The high end is bright and precise, and the bass is tight and controlled, while still retaining that signature warmth and power. That said, make sure you give it a decent signal. Low-quality files sound harsh and hollow—you can really hear the flaws. You'll need a decent DAC or soundcard. The Eggs hold up against equally expensive hi-fi equipment, but where they really come into their own is when you're using them to produce music. They give such a clean, accurate response that you know exactly what's going on in your mix. Vocals sound like the singer is right there in the room with you. We spent hours chopping up samples, and programing beats at high volume, and our ears never tired at all. Our only gripe with the Egg150's younger brother, the Egg100, was that when working with really bass-heavy material, it struggled a bit—not so with the Egg150. It plays low and deep effortlessly.

So, should you buy the MunroSonic Egg150 monitors? Well, if you're just after some amazing speakers for your rig, and have the cash, then as long as you're packing a high-end DAC and a hard drive full of high-def audio files, or have a subscription to a high-def streaming service, such as Tidal, they're damn near perfect. But, if you wanna watch YouTube vids, and stream from low bitrate sites, well, be prepared for them to sound terrible. If you're a music producer, you'll really want these speakers in your studio. Your mixes will come alive like never before, the amp is so nice to use, and the whole system looks stunning. For professional use, we really can't fault them. **–ALASTAIR MARR**

VERDICT
9
KICK ASS!

MunroSonic Egg150

+ CRACKING Fantastic sound; looks exceptional; absolute top quality.

− SCRAMBLED Shows up poor audio for what it is.

$3,000, www.munrosonic.com

SPECIFICATIONS

Tweeter and Driver Size	25mm and 100mm
Effective Internal Volume	14l
HF Unit Sensitivity	95dB SPL 1W at 1m
LF Unit Sensitivity	89dB SPL 1W at 1m
Total Amplifier Wattage	200W

Razer ManO'War

The wireless conundrum

HERE WE GO AGAIN: another month, another wireless headset, another offering to the gaming gods of wireless peripheral fury. The Razer ManO'War is nothing short of awe-inspiring to look at it. Its clean lines, simple black design, and elegant feel will appeal to those looking for a more premium headset. It's a step away from the more outlandish offerings Corsair recently brought to the table, and far bulkier and classier than Turtle Beach's wireless headsets, as well. But, alas, looks are only one part of the story, and there's more to tell when it comes to the ManO'War.

It's safe to say we've not always been fans of Razer's more recent cans here at *Maximum PC*. The Kraken Pros, for instance, lacked the higher reaching treble found within the likes of the HyperX Clouds or Corsair's USB Voids. Coupled with the overwhelming gaming bass, basic comfort options, and overall pricing structure, it all felt just a little out of touch. Fortunately, the ManO'War looks to correct that.

NOT ALL ABOUT THAT BASS

The ManO'War features 50mm dynamic drivers, with a frequency response ranging from 20Hz to 20kHz—nothing particularly exceptional, then. The impedance is the standard 32 Ohms, and SNR sits at a decent 112dB. What Razer has managed to work in here is some exceptional EQ balancing. As standard, the ManO'War sounds crisp, well balanced, and rounded. Its mids and trebles are solid and dependable, its bass not too overpowering. Certainly, it seems to have avoided the "gaming syndrome" we suffered from the Kraken Pros.

However, the soundscape isn't as wide as we'd expect from a headset at this price, no doubt due in part to that limited frequency response. It's most noticeable when comparing it to other headsets in its price range. Take Sennheiser's G4ME Zero—with a frequency response of 10Hz–26kHz, those mighty cans dominate the performance category at this price. Does it make a difference? After all, human hearing supposedly only operates from 20Hz to 20kHz. In our opinion, yes, it really does; in the same way it makes a difference listening to a FLAC audio file as opposed to an MP3. The lower and upper sound frequencies buried within each piece of audio can resonate, can ring out without being cut off at the tip. That's not to say that the audio quality is bad on the Razer ManO'War, just that it could be better.

Audio quality aside, the ManO'War performs admirably. The range is good, the microphone a strong contender, and the overall look and design great. The earcups are exceptionally comfortable, and the semi-open back style keeps you aware of your surroundings in and out of game. On top of that, it provides a bit of relief when your ears get too hot. But it's not all roses. The headband is a little on the thin side, and the sharp angles and edges of the plastic frame covering the metal support band can cut into your head a little, certainly if your hair is either missing or shorter than most people's.

As for battery life, the ManO'War is rated to operate for a total of 14 hours of continuous use with the LEDs on, or 20 hours without. We can't understand why you'd want to run this headset with LEDs on, for as much as they look great, it doesn't make sense to part with six hours of battery life, all for the sake of something you can't even see when you're using it. In testing, we plugged the headset in at night, every night. Just to be safe. It saves faffing about with a cable mid-game.

All in all, Razer's ManO'War is a solid enough headset, just as long as it's in the right hands (or on the right head). If you're careful with your positioning, have a full head of hair, and don't mind the simpler soundscape, then it's ideal. However, for us, there are simply too many kinks to let both it and wireless headsets in general off the hook just yet. **–ZAK STOREY**

VERDICT 7

Razer ManO'War

+ BLACK PEARL Well-balanced audio; solid accessory kit; good battery life when LEDs off; quality mic; impressive EQ options.

− FLYING DUTCHMAN Narrow soundstage; relatively expensive; uncomfortable headband over time; angular housing; illogical LEDs.

$170, www.razerzone.com

SPECIFICATIONS

Driver Type	50mm dynamic
Impedance	32 Ohms
Frequency Response	20Hz–20kHz
Microphone Type	Unidirectional retractable mic
Connectivity	USB
Range	40 feet
Battery Life	14 hours LEDs on; 20 hours LEDs off
Weight	13oz

Audio-Technica ATH-MSR7

High-res audio headphones from the aural heavyweight

LIKE IT OR NOT, it's not always possible to have your PC audio piped out from your glorious 5.1 surround sound setup. However awesome your taste in music, your room-mate or significant other may have different (obviously worse) tastes, and might also not appreciate the sounds of your current fantasy realm/post-apocalyptic nightmare of choice booming out at all hours of the day and night.

What are you to do? Get yourself a serious set of headphones in order to jealously guard your spectacular audio taste, and keep it from the ears of others. They simply don't deserve it.

While a great many PC headsets are aimed at gamers, there is a rising tide of users eschewing gaming headsets' overblown bass tones in favor of the more accurate audio of high-end headphones. Audio-Technica has a great heritage in that field—which has also lead it to create some impressive gaming headsets recently—and the ATH-MSR7 aims its sights squarely at the high-resolution audio arena.

High-resolution audio is essentially defined as anything above the standard CD-quality level, and with a bountiful specs list, the MSR7 cans ought to be a great match for that headphone amp you've always wanted to plug into your PC.

They've also obviously been designed for this post-Beats world, where it's no longer weird to be seen walking around with a hefty set of headphones strapped to your braincase. The plush leather headband and ear cups, together with the aluminum-coated surrounds, help give the MSR7 headphones that high-end aesthetic. Though we have to admit, we'd rather have the less showy black option, as opposed to the gun-metal gray version we've been testing—the brown, gray, and red mix doesn't really sit too well with us.

But these aren't Beats headphones—the audio quality actually matters with the MSR7. And in that, it's a fine set of cans. Though for $250, we'd have hoped for something a little more than just "fine."

The tonal separation to the MSR7, though, is impressive, enabling you to pinpoint different audio notes, and in well-produced songs, you get a great feeling of space to the instrument positioning. The fact it seems to have a relatively flat EQ is in itself not a problem; we'd rather have more accurate audio than unnecessarily over-emphasized bass response. The MSR7 does lack a little punch at the low end, but it remains detailed and controlled.

CHAIN REACTION

There is a certain lack of depth, though. When listening to proper 24-bit/96kHz high-res audio tracks, you've got all the aural data there to produce spine-tingling experiences, but we never seemed to hit those genuinely affecting heights. At the crescendo of Fleetwood Mac's *The Chain*, we want the mix of driving bass and choral highs to make the hairs on our arms stand to attention, but Stevie Nicks and Christine McVie's vocals tend toward harsh with the Audio-Technica headphones.

In-game, however, that tonal separation makes it a decent fit for your PC's high-end audio components. Running through a discrete high-quality soundcard, the MSR7 recreates game audio admirably, delivering a wide, detailed soundscape.

The difficulty for Audio-Technica is that there is a great deal of competition at this price point; from its own high-end gaming headsets, for one. The ATH-AG1X cans are detailed, expansive, and come with a high-quality mic—the MSR7 headphones have to make do with a limited condenser mic on the detachable cables they come with. All told, Audio-Technica's MSR7 headphones are a decent option for your audio, but they generally fall short of being anything more exciting than that. **–DAVE JAMES**

VERDICT 7

Audio-Technica ATH-MSR7

⊞ **HIGH-RES** Excellent frequency response; detailed, spacial audio; comfortable.

⊟ **HIGH-ATTRITION** Lack of aural depth; weak passive noise-canceling; slightly harsh high-ends.

$250, www.audio-technica.com

SPECIFICATIONS

Driver Type	45mm dynamic
Impedance	35 ohms
Frequency Response	5Hz–40kHz
Design Style	Closed back
Microphone Type	In-line mic
Connectivity	3.5mm analog
Weight	10oz
Cord Length	4ft/10ft detachable

Phanteks Enthoo Evolv ATX Glass

The Evolv strikes back

USED IN BUILD IT PG. 66

PHANTEKS HAS BECOME legendary for its innovative case designs. By no means has the Dutch company created revolutionary changes, more evolutionary advances. Advances that have been picked up by many a case manufacturer looking to improve its lineup. So, what are we talking about? Rear SSD mounts on the back of the motherboard tray and on the front of the chassis, simple yet effective integrated PWM fan hubs, a slide-out fan/radiator mount in the top of the chassis, improved airflow, thanks to cleverly designed perforated front panels, ITX form factor towers capable of housing even the most boisterous GPUs, and some curious rear I/O 5.25-inch drive bay mounting solutions.

So, to the case in question. The Evolv ATX Glass is Phanteks' fourth iteration of its Evolv range. The original Evolv we reviewed late last year was impressive. In fact, it impressed us so much we awarded it our prestigious Kick Ass award. Its sharp lines, innovative design accessories, use of materials, and ease of access, as far as system building went, was astonishingly impressive. So, what's changed since then?

Not a lot, but that's not necessarily a bad thing. The introduction of two smoked tempered glass side panels, instead of metallic hinged panels, is the main focus of this edition, and they look gorgeous. The reflections glinting off the side give it a sense of premium that you just can't get from acrylic. They're the perfect mates for the 3mm-thick aluminum panels covering the exterior surround. They're about 5mm thick, and durable enough to take any reasonable form of beating, not that it should be an issue.

One thing you need to be wary of when investing in this chassis is the rear side panel. Unlike many other glass paneled cases, it's entirely transparent, so your cable management is going to need to be seriously on point if you want to showcase your new machine.

Glass aside, what do we love about this chassis? We've mentioned the 3mm-thick aluminum panels, but on top of that, it's a semi-compartmentalized chassis, with a full perforated floor panel separating the PSU from the rest of the system. It has three 2.5-inch SSD mounts, one on the front for display purposes, and a further two attached to the rear of the motherboard tray. There's support for up to three 3.5-inch hard drives hidden below that PSU cover, and a fan hub capable of powering eight fans off a single PWM motherboard header and SATA power, alongside RGB LED lighting control inside the front panel.

As far as cooling is concerned, you have the option to install up to six 120mm fans in both the front and the roof, alongside an additional 140mm in the rear, and you can fit up to two 360mm radiators in here as well. What's particularly impressive is the removable fan tray at the top of the case. Removing a couple of screws enables you to slide out the tray to mount your fans and radiators directly, saving you the hassle of struggling to fit them inside the chassis.

To wrap up: huge cooling support, clean stylized design, internally and externally, fantastic accessory support, and available in three different colors. What's not to love? Criticisms are slim on the ground, but there's two things we'd like to point out: There's no option for a 5.25-inch bay, although that's not a huge deal, and there's no non-windowed edition available. Apart from that, this baby is on fire. –ZAK STOREY

VERDICT 9 KICK ASS!

Phanteks Enthoo Evolv ATX Glass

+ **HOMO SAPIENS** Classy glass panels; 3mm aluminum; premium feel; huge feature set; RGB lighting controller; SSD mounting points; PSU cover; extensive cooling support; removable radiator mount.

– **NEANDERTHAL** Prone to smudges; cable management skills needed.

$190, www.phanteks.com

SPECIFICATIONS

Form Factor	Mid-tower chassis
Motherboard Support	E-ATX, ATX, microATX, Mini-ITX
Available Colors	Black, gray, silver
Window Available	Yes
3.5-Inch Support	8 (5 included)
2.5-Inch Support	3 (2 included)
Radiator Support	360mm roof, 360mm front, 140mm rear
Fan Support	3x 120mm front, 3x 120mm roof, 1x 140mm rear
Dimensions	9.3 x 19.5 x 20.1 inches
Graphics Card Clearance	16.5/11.8 inches
CPU Tower Clearance	7.6 inches
Weight	22lb

Asus ROG Spatha

Huge hands required for Asus's latest desktop beast

WE HOPE YOU LIKE A BIG ONE. The Spatha is so wide and long, it makes other mice look puny, and going back to an office-supplied mouse after using this bison of a pointing device, you feel as though it's about to lift off the desk, such is the heft and weight on offer from Asus.

Just opening the box is an experience. The mouse, its charging cradle, hard case, cable, and all the other tat that's part of the modern mouse-buying experience come in a black cuboid that gives a solid whomp when dropped on a table.

An MMO mouse, the Spartan features the usual button cluster, customizable lighting, and a tiny bit of flash storage for your customizable profiles from the usual Asus software. A magnesium alloy chassis is to blame for all that solidity, but even the plastic, plated liberally over it, appears to be thicker than we've come to expect. This means it's a mouse that should take some punishment, especially if you're the sort to punt your gear across the room when sniped.

You'll be able to get it quite a long way, too, not only because of the increased momentum that depleted uranium chassis imparts to it, but also because it's wireless. The 2.4GHz RF connection should provide enough bandwidth for that 8,200 dpi sensor, and if the battery light starts to blink, a micro-USB cable can be plugged in, so you can carry on doing whatever it is you do while charging. A battery capable of powering the lighting and wireless capabilities probably explains some of the size and weight, too. The Spatha is happy to work in a purely wired mode, if you don't want to plug the dongle in.

On top, the two main buttons float free from the rest of the case, and can be clicked by pressing anywhere on their significant length, although it gets harder the further up the body you get. Asus claims the shape is designed with both palm- and claw-grippers in mind, but palmists might get on better—clawers are going to need some awfully long fingers to move efficiently from button to button. The wheel is a minor disappointment—its light feel at odds with the solidity on offer elsewhere—but it's so tightly held in place that there's no wobble from side to side. A sniper button also sits on the top, needing to be switched on and off, instead of held down, but still in exactly the wrong place for lowering the sensitivity while lining up a tricky shot.

The Spatha sports 12 programmable buttons, six of them under the thumb that look like Adam Jenson just smashed a window, their triangular pattern guiding you toward the front two but leaving the smaller central button—looking so much like the pupil in the eye of some hideous mechanoid that we wish they'd put a light behind it rather than just at the edges—a lot harder to find and push. The body's remarkable length means that, even in the hand of our specially trained mouse-testing sasquatch, triggering the front-most button next to the primary button, followed by the rear-most button under the thumb, requires a bit of stretching, and even a repositioning of the entire hand.

With the Spatha, Asus has built something more like a status symbol than a simple mouse. The charging cradle is a plinth on which to show it off, the three-zone lighting able to make it look like a classy part of a well-thought-out collection (or a garish mess), even if an all-over matt black color scheme could be seen as playing it safe. It's over-engineered, but this imparts a solid precision to its movements. With replaceable switches (Omrons rated for 20 million clicks) and some thoughtful button placement, this is a mouse that demands to be tried, even if the price might send many gamers in search of something a little less rich. **–IAN EVENDEN**

VERDICT **7**

Asus ROG Spatha

+ **ENGINEERING** Solid build; precise; not too much lighting.

− **IMAGINEERING** Some buttons hard to find; wheel not the best; expensive.

$160, www.asus.com

SPECIFICATIONS

Sensor	Laser
Sensitivity	400–8,200 dpi
Sensor Model	Pixart ADNS-9800
Polling Rate	Up to 1,000Hz wireless, 1,500Hz, 2,000Hz wired
Programmable Buttons	12
LEDs	Tri-zone, 16.8 million colors
Cable Length	6.6 feet
Weight	6.3oz

Faith isn't really the star—the city is.

Mirror's Edge Catalyst

Might as well jump!

A GAME EVERYBODY LOVED, but few played, *Mirror's Edge* put you in the fashionable shoes of Faith, a runner who can carry messages without attracting government attention in her near-future dystopian home. This was in 2009, and the game was criticized for poor combat, contrived levels, and an inconsistent sense of speed, even as reviewers gushed over its bold, stylistic choices, and unconventional nature.

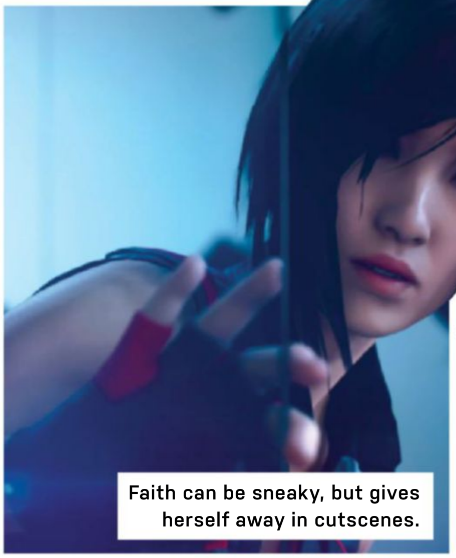
Seven years later, today's *Mirror's Edge* looks amazing. All *Blade Runner* screens and Neo-Tokyo lighting, this is a place of empty warehouses, planks across drops, railings right where they need to be, and pipes that end at just the right height. Contrived? Maybe, but only in the way that every game space is contrived in order to make it playable. Fall in a pit and there's a way out, rather than leaving Faith to starve to death, or until a builder arrives to help her up. Despite its modernist good looks, however, the city is underpopulated and lacks character.

Fresh out of a two-year prison stretch, during which she's managed to cultivate a sharp haircut, Faith immediately gets her old job back. Supervised by the deeply irritating Icarus, she soon begins delivering packages and breaking into company headquarters in a newly more-open-world city (it's not a true open world, really), where people hang around on rooftops to offer you side missions, there's always more than one route to a target, and the ground seems a very long way down.

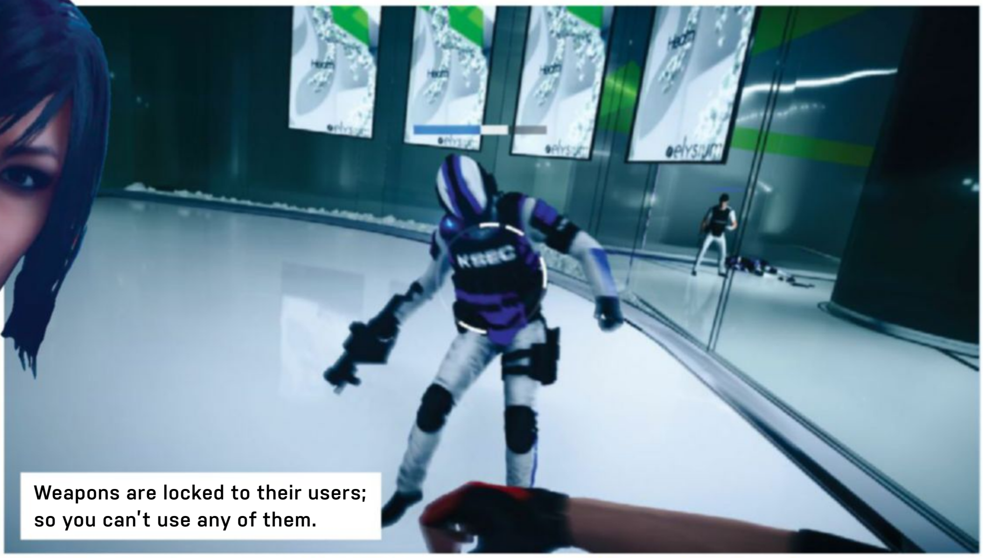
An irritating early mission sees Faith tasked with retaining Focus—a bar that fills as you run—while she makes her way through security guards to a dead drop. There are several things wrong with this. Firstly, the number of guards suggests the bad guys know where the drop is, defeating its purpose. Then there's the "not losing Focus" part, which fails the mission if you run past a guard instead of thumping him, in a game that's told you it's often better to avoid combat, and makes you invulnerable to damage as long as you keep running. Then it fails you for using the "wrong" attack to take them down—light attacks only in this situation. It's a frustrating sequence that becomes a challenge of rote-learning, rather than skills.

There are other non-optional combat sections throughout, and the developers have made a valiant effort to make them bearable by building a melee fighting system around the traversal. Spring into the air or slide into a guard, and you do extra damage, often taking them out immediately. Much like certain aspects of the movement controls, especially wall-running, it's often not clear whether you'll land a blow. It's not that the game is unresponsive, as it proves itself time and again to be a smooth and fast-flowing affair, the Frostbite engine holding its framerate well on our test rig's GTX 970 and mostly Ultra settings. The game also comes with a Hyper setting, aimed at those with GTX 1080 cards and 2.5K monitors—even on this, it'll hold 60fps.

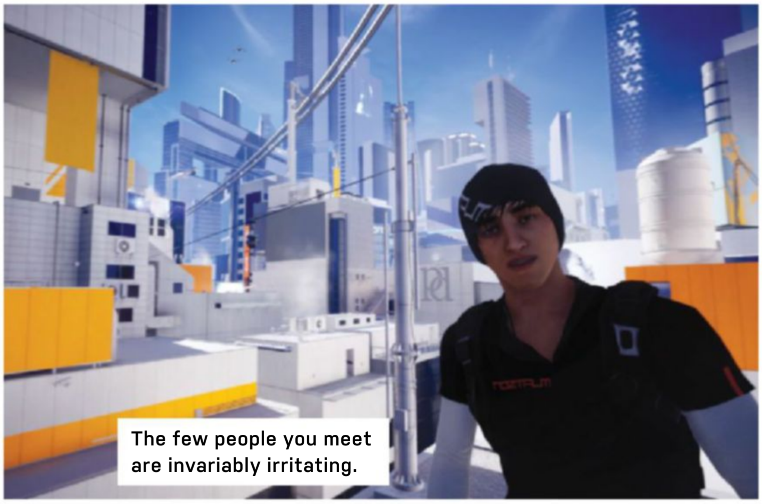
No, the problem seems to be one of direction. The radius within which Faith will change direction mid-air to land a blow is wide, and when charging at security guards, we've seen them suddenly change direction to move back into our path, the better to bop



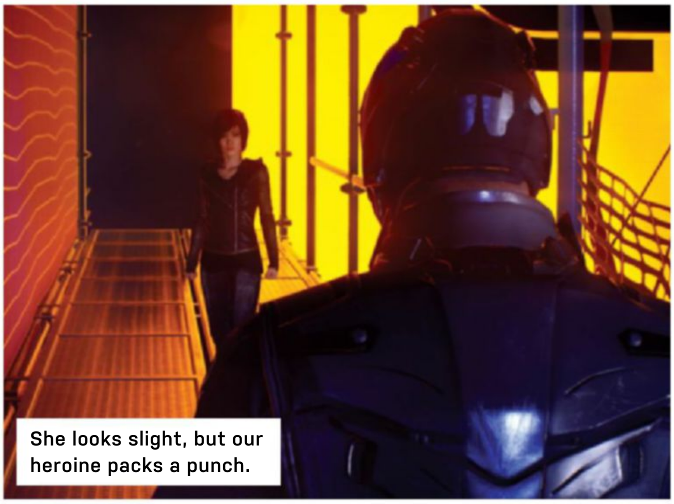
Faith can be sneaky, but gives herself away in cutscenes.



Weapons are locked to their users; so you can't use any of them.



The few people you meet are invariably irritating.



She looks slight, but our heroine packs a punch.

them. But when attempting wall-runs, a wall can't do this, and we found ourselves in a pit or flailing at the air many times because we weren't perfectly lined up.

AID RUNNER

Faith is guided in her wanderings by her Runner Vision, an augmented contact lens that shows her a route—not always the fastest—to her waypoint with a red swirl, and highlights in red the objects she can use to ease her path there. It becomes very much a game of "run at the red things," and this visual feedback enables you to chain moves together into a blur across the rooftops. Time trials enable you to show your mastery of the system, with the online leaderboards every game must have these days, and the ability to create your own to share with friends. You get to choose what information Runner Vision displays, or turn it off if you want more of a challenge. It's switched off in certain areas to make you think more about your surroundings, too.

Something else that every game must have is an XP system, complete with unlockable abilities. *Catalyst's* fits rather awkwardly with the game—many skills are already unlocked when you start playing, the useful quickturn becomes available very early on, and one particular mission acts as a barrier to unlocking a great many more. It's an odd addition to the game, especially as DICE has chosen to leave XP-boosting pickups dotted around the city. Floating orbs can be run through, but documents and control chips make you pause to collect them. It's another addition that might have benefited from a little more thought at the planning stage.

Enemies come in armored varieties, with some carrying guns that you can't actually take from them, so it's important that you can beef up your character for the escalation of the game. Improving your stamina is one thing, but protective vests and grappling hooks, made available by gaining experience for a character who was previously at the top of her skill set, undermine the internal logic somewhat.

Catalyst is certainly a beautiful game, and could have been a great one, too, if its systems were as well designed as its sumptuous visuals. As it stands, it can be frustrating to play, yet when it gets it right, it gels together into a celebration of fast, clever traversal, which is capable of firing up adrenaline and even vertigo. In a marketplace that's recently seen *Doom* and any number of man-in-the-dark-with-a-gun games, this stands out as a ray of sunshine, and after the reception of the first game, it's a sequel that we are lucky to be able to play at all. **–IAN EVENDEN**

VERDICT

7

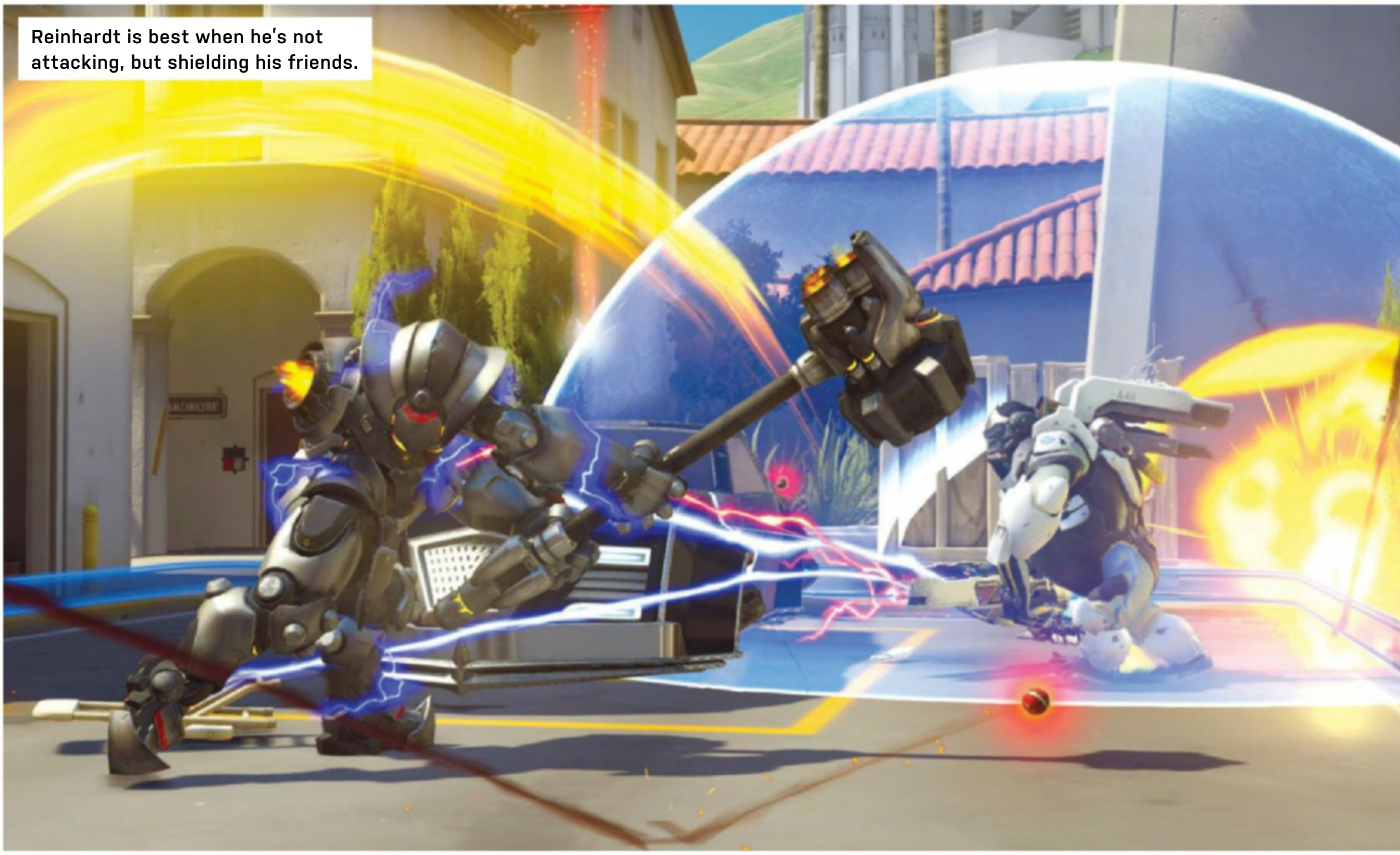
Mirror's Edge Catalyst

+ CATALYST Pretty, well-designed city; a break from the norm; runs smoothly.

− OOPS-I-MISSED Frustrating combat; occasionally iffy controls.

RECOMMENDED SPECS Intel Core i7-3770 @ 3.4GHz or AMD FX-8350 @ 4.0GHz; 16GB RAM; GeForce GTX 970 4GB, AMD Radeon R9 280X 3GB, or better.

$60, www.mirrorsedge.com, ESRB: T



Reinhardt is best when he's not attacking, but shielding his friends.

Overwatch

Blizzard's magic sparkle pen makes the shooter shine

BLIZZARD HAS MASTERED the polished, bite-size experience. From *Hearthstone* to *Heroes of the Storm*, it has shown that games can appeal to the hardcore gamer while being casual as anything. *Overwatch* is its application of that to the team shooter.

In a game of *Overwatch*, two teams of six wacky warriors fight over a range of colorful maps. The battles last 10 minutes at most, so it's ideal lunch-break or drop-in, drop-out fodder. Anything that traditional team shooters had that gets in the way of your fun and could be dropped, has been.

So, there's none of the tedious pre-game buying decisions of *Counter-Strike*. There's none of the madly varied character equipment or customization of *Team Fortress 2*. Though there are loot drops, they're purely cosmetic—new skins, victory poses, wall sprays, and voice clips for each character. Unlike *Battleborn* or *Dirty Bomb*, there's a nice array of characters (21), with every single one available from the word go. And it costs a set, cheap fee of $40.

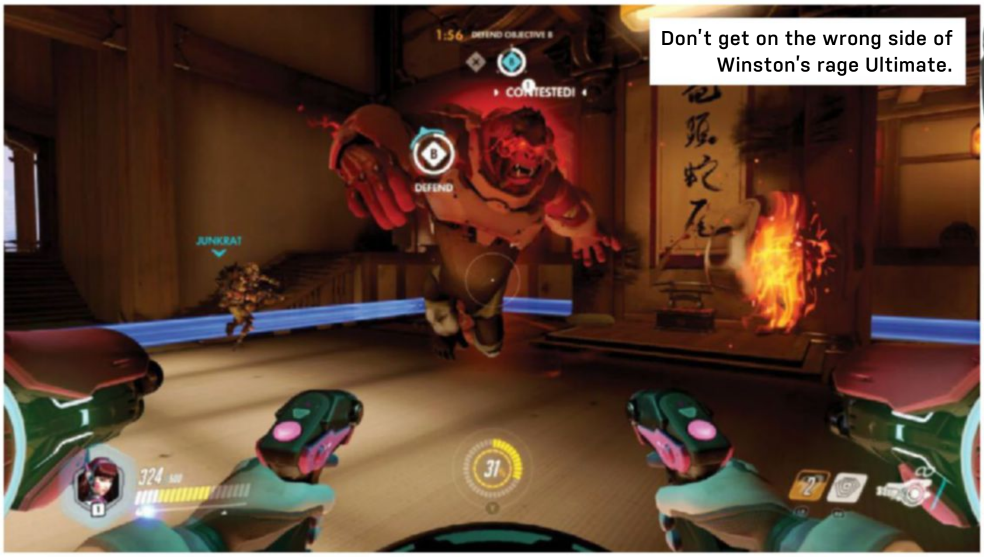
The character design is in-your-face superb, and you'll almost certainly be seeing all these characters appearing in Blizzard's newbie-friendly MOBA *Heroes of the Storm* over the coming years. Look at Tracer, the game's iconic character. She's a body-suited teleporter with ski goggles, dual pistols, and a cheeky grin. Reinhardt, meanwhile, is a clunking great suit of armor, with a hammer, shield, and cod-Teutonic voice. Every character shares that jovial attitude, like they're in this for a laugh, just as you are.

The design means that the character silhouettes are just right too—you can tell instantly whether you're going up against a tank, a damage-dealer, or a support character—and half a second is enough to know which one and whether you should run. Play for half an hour, and you'll know almost everything about how to play.

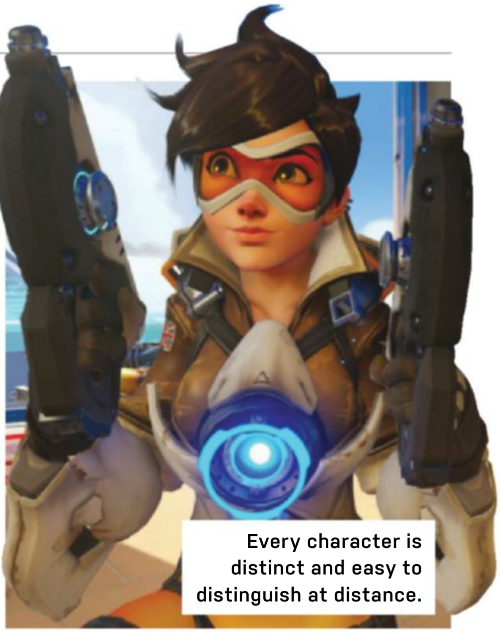
And though the characters are assigned traditional MMO classes, such as offense, defense, tank, and support, the classes are very loose, with the characters varying massively in their behavior and capabilities. Take the support class as an example. There are four characters in this class: Mercy, Lucio, Symmetra, and Zenyatta. The gliding Mercy is the only out-and-out healer (and even she can choose to buff a friend's damage instead). Lucio can run up walls, and buff friends' speed or health. Symmetra sets up teleporters and sentries, and can shoot through enemy shields. And Zenyatta is a floating robo-fakir, who can buff friends and debuff enemies. Each of them is fun to play, and is completely unlike the others.

That points up something else. No button does the same thing, from character to character. You'd expect Shift to be a run button—and with Soldier 76 it is—but it does different things for each character. Mercy's Shift button lets her fly immediately to a friendly character; Zenyatta's is an Orb of Harmony, that continuously heals a friendly character; Lucio's switches between his healing and speed-buffing soundtracks; and Symmetra's throws out up to six miniature sentry turrets.

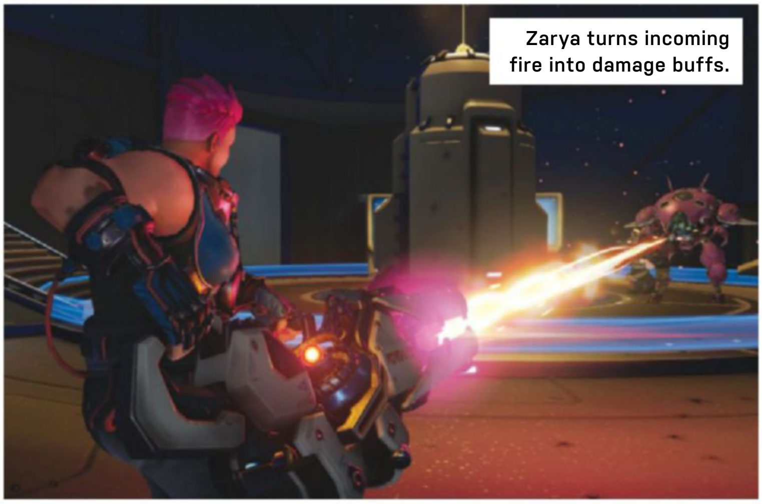
Although that sounds confusing, the game holds your hand all the time. Whenever you play a new character, it prompts you to press F1, which reveals their



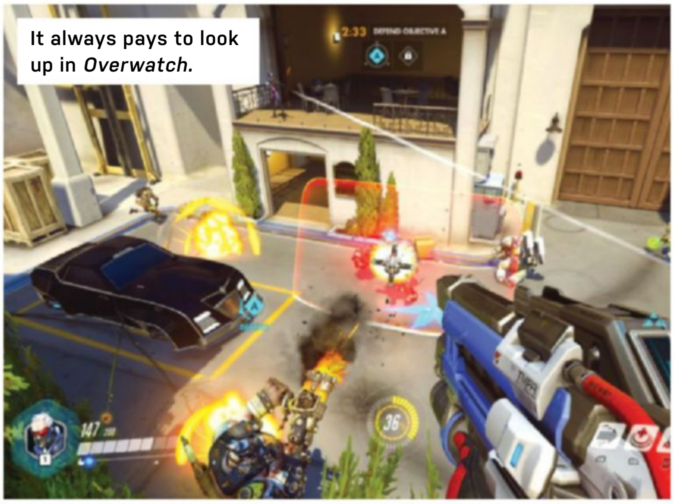
Don't get on the wrong side of Winston's rage Ultimate.



Every character is distinct and easy to distinguish at distance.



Zarya turns incoming fire into damage buffs.



It always pays to look up in *Overwatch.*

abilities. There are only really five abilities, at most, so it's quick to learn a character—and if you're suffering, a quick bash of the H button changes you to another one. (The game suggests which one your team needs, too.) There's a training mode, if you really need it, but playing is the best way to learn.

Similarly, although the maps look complex, with great verticality, length, and side passages, they're not. All those side passages lead back to the action, so every fight tends to involve most of both teams pummeling away, with the more mobile characters attempting to flank the tanks to kill the snipers and medics behind them. The missions are equally straightforward and familiar—escort the payload, capture the point, and so on.

The core combat systems are easy to learn (for FPS veterans, at least), and fun to play, too. As each character is so unbalanced and varied, you're endlessly switching tactics, as is the enemy. Sometimes you're hiding behind Reinhardt's giant shield, prompting the other team to change to characters who can flank you or shoot through it. Other times, you're popping Junkrat's grenades over a wall and never seeing the enemy except through Widowmaker's shared targeting Ultimate ability. (Each character has an Ultimate, which takes time to charge, and can be a complete game-changer—for example, Mercy can bring every recently deceased player nearby back to life, or Pharah can rain down a rocket barrage from on high.)

Despite how pared-back it is, there's a few more options than just Quick Play. You can also create Custom Games for your friends—and the options are powerfully silly, enabling you to play around with health and super levels, ban characters, give everyone random characters, and much more. There's also a weekly shifting special game mode (akin to *Hearthstone's* Tavern Brawl), which mixes up the gameplay like a Custom Game, but for public games.

Technically speaking, the game is solid as a rock. You can get into most games in under a minute, and we've never dropped out from server issues. It runs well on basic hardware, it places you reliably into matches with people of similar skill, and it's updated regularly, so any problems and balance issues should be solved quickly.

Fans of *Team Fortress 2* will appreciate *Overwatch* the most—it's very much a cleaned-up, cut-down version of Valve's classic. Our only concern is over its longevity—we don't know how many people will play it long-term, except maybe lovers of esports. That said, it's slick, fun, and endlessly rewarding, and a great game to get into right now. **–DAN GRILIOPOULOS**

VERDICT 8

Overwatch

+ OVERJOYED Iridescent; compelling; perfected; balanced; cartoony.

– OVERSIMPLIFIED Limited maps and missions; limited play styles; no ranked play yet.

RECOMMENDED SPECS Intel Core i5 or AMD Phenom II X3; GeForce GTX 660 or Radeon HD 7950; 6GB RAM; 30GB storage.

$40, www.playoverwatch.com, ESRB: T

LAB NOTES

ZAK STOREY, STAFF WRITER

Liquid-Cooling Education

The woes and weaknesses of human error

YOU MAY RECALL a couple of issues back that we did an extensive Build-It and feature on hardline liquid cooling. It was my baby—14 pages of water-cooling goodness and a system build, crammed into 5,500 words.

Alas, the story never quite ends when it comes to liquid-cooling. In fact, that was only the beginning. But after three months, the conundrums that bugged me with the first "final" build have now been resolved. These conundrums mostly came about because of human error on my part. During my wanton abandon, I idiotically ignored the instructions on including the correct extender fitting on the inlets of my reservoir, so I suffered a tiny leak and the death of two pumps (yep!)—a harsh learning curve for myself. After some discussion with my water-cooling contacts and modders from across the tech journosphere, we came to the conclusion that I was either running too many components off a single Molex rail, that the pump, following a slow-rise fan curve on Asus's Q-Fan software, was burning out because of it, or that it was the tiny leak that caused the problems.

So, I ordered in a custom reservoir top, reconfigured the tubing to run into the top of the res, got hold of an NZXT Grid+ V2 fan controller, swapped the pump over to a separate Molex rail, and even managed to reconfigure the back of the loop, so it didn't have a slight slant. All in all, she's running as slick as a whistle now. And with a quick re-orient of the fans, temperatures are six degrees lower, thanks to an increase in positive pressure internally. Which makes me one happy staff writer, that's for sure.

There's still a few things I'd like to change. Namely swapping the fans out for some of Corsair's latest maglev LED SP variants. And I'm also toying with the idea of swapping out the white EK coolant for Mayhem's black or clear instead.

Behold—the Manta's final form.

TUAN NGUYEN

Editor-in-Chief

I've been a fan of *nix-type operating system for decades. Robust, lean, efficient, and speedy, it's what I use on my home servers. On the desktop side, one of the most popular is Apple's OS X—now called macOS. I've been using macOS for a while, but not on a Mac. I've built several hackintoshes. They all run stable, and all the hardware features are fully and natively supported. The key is to pick the right components. Intel CPUs are preferred. Then a Z170 motherboard. Those who need more processing oomph can opt for an X79 or X99 mobo. All Nvidia cards are supported with Nvidia's web drivers, except for the new GTX 1080 and 1070 cards. How do you install macOS? Let me Google that for you.

ALAN DEXTER

Executive Editor

The likes of the GeForce GTX 1080 may grab the headlines, but such cards won't impact the PC as a platform that much—there won't be enough high-end GPUs out there to make it financially viable to exploit every last slither of such silicon. It's the likes of AMD's next collection of GPUs—the RX 480, 470, and even 460—that will really shift things forward. Not from a raw performance perspective, but from the fact that such cards will sell by the bucketload. And that means that the capabilities of your average PC will improve enough for developers to sit up and take note. Without that mainstream pushing things forward, the platform would have stagnated long ago.

Editors' Picks:
Digital Discoveries

Alex Campbell, Associate Editor, and Jarred Walton, Senior Editor, reveal their tech loves

UBUNTU 16.04 LIVE USB

There are a few things I like to keep around as a PC enthusiast. A screwdriver is obvious, as is the occasional can of compressed air. But one thing I've found a ton of use for is a USB thumb drive loaded with a copy of Ubuntu.

If you boot to the USB drive, you can start using Ubuntu right away, without any need to install it as your main or secondary OS. This is great if you're just Linux-curious, or want your own OS that you can fit on a keychain and take anywhere. When running Ubuntu from a USB stick, the OS is normally non-persistent (when you reboot, everything you've done is gone). However, you can set up a persistent installation if you use UNetbootin to copy Ubuntu to the USB drive. With a persistent install, you can have a personalized OS you can take anywhere, with all your configs set how you like them.

Even if you're running Windows, having an Ubuntu live USB is a good idea. There's been more than one time Ubuntu has saved my bacon, allowing me to remove malware and spyware. It's even handy for backing up your data if Windows won't boot on its own.

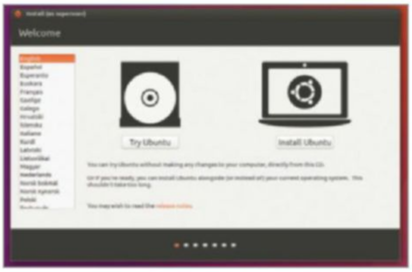
There's really no reason not to have an Ubuntu live USB, as the only thing it will cost you is the price of the USB flash drive itself.

GEFORCE GTX 1070

Not everyone who loves PC hardware is a gamer, but I certainly am, and if there's one component that matters more than anything else for gaming, it's your graphics card. The best hardware also costs a lot, but dropping down a notch is a great way to maximize value without having to compromise on performance.

We've reviewed the GTX 1070 on page 72, and to me it's by far the most exciting GPU in the new line of chips coming from AMD and Nvidia. It's faster than a GTX Titan X or a 980 Ti, and priced only slightly higher than a GTX 970. If you've been struggling along with a previous-generation GPU, the 1070 will enable you to max-out image quality in most games, while still running 1440p at 60-plus frames per second.

We might lust after the GTX 1080, and we can dream about AMD's Vega 10 and Nvidia's Volta, but the GTX 1070 is here, now, and it packs a serious punch for the price. I recently calculated fps per dollar spent on a graphics card, and the GTX 1070 came out on top. Who's playing second fiddle now? There will always be something better right around the corner, but the waiting game is no fun. Upgrade to a new GPU right at release, and you can enjoy it for years to come.



GEEK TESTED & APPROVED

Fujifilm X70 Compact Camera

A TECH JOURNALIST needs a solid and dependable camera. Photography and video are a central part of our job, and although you can get away with a good smartphone, nothing compares to a true APS-C sensor.

For me, that sensor comes in the form of Fujifilm's X70. It's a fixed-lens, lightweight, small form factor street camera I can just pop in my pocket. Its 18.5mm wide-angled lens, coupled with the 16.3MP APS-C sensor, is more than enough to satisfy my needs. Video-wise, the X70 supports 1080p at up to 60fps, for a grand total of 14 minutes in a single shot—enough for all my vlogging aspirations. But what blows me away is the screen. Capable of pivoting up to 180 degrees, it enables you to line up some brilliant shots without breaking your body—it's also great for, er, selfies, too.

Then there's the hotshoe mount point for external devices, microphone input, a variety of aperture, shutter speed, and exposure settings, all controlled via a plethora of dials, and Wi-Fi for the quick transfer of images. Downsides? Well, there's no image stabilization built in, and although the integrated microphone is fantastic quality, it does have a habit of picking up the clickings of the internal mechanisms, as the lens focuses on your face. All can be side-stepped with the use of a dependable tripod, aftermarket software, and a dedicated microphone, but even so, it's something to bear in mind. Need proof of how good this little beauty is? Check out my handiwork here: http://bit.ly/MPC1080. **–ZS**

$700, www.fujifilm.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> MicroATX Build Issues
> RAID Rationale
> Power of Pi

Micro Machine

I'd really like to see you do a microATX 4K build. I'm researching doing one myself, and would like some advice. The main problem I have is my little one pressing buttons and messing with my system. So, for its safety and his, I want to put a microATX system, strong enough to push 60-plus fps at 4K, on my desk and out of his reach. My initial thoughts were to use two GTX 980Tis in SLI, but with the recent release of the GTX 1080 and GTX 1070, I have thought about changing my mind. I have had a hard time, however, finding data on SLI 4K specs for the 1070 and 1080. So, should I buy two used GTX 980Tis to save money, get two new GTX 1070s (assuming they are enough), or two GTX 1080s? Thanks for the help.

–Channing Maddix

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We relish a challenge here on *Maximum PC*, and this will certainly be a challenge. What you've requested is certainly possible in theory, although staying on top of the thermals here is the real task—keeping a pair of graphics cards cool in such a tiny space will need some clever planning. Instinctively, we think that the cooler-running Pascal cards (GeForce GTX 1080 and 1070) are the way to go, because the 16nm production process means power requirements are lower, so heat production is down, too. But keep your eyes peeled for a future issue, where we'll build exactly what you're looking for. And if anyone else has any ideas for Build It that you'd like us to try to solve, please drop us a line, and we'll see what we can do.

GIMPing Photos

I appreciate all your articles regarding photo-editing tips and tricks. Only one problem: I'm not paying Adobe a crapload of money for its software, as I'm not a professional, and I'm sure as hell not going to steal it. So, how about you write these tutorials using GIMP? Adobe pros will figure out the different terminology, while newbies, like me, can still tinker and try to have some fun.

–Paul

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We have run a couple of GIMP-specific tutorials in the past, and I'm sure we'll run some more in the future, as well. There are a few differences between the packages, which is why we do try to cover such things in a boxout for that specific tutorial. This could go both ways, though, and we'll try a selection of both, focusing on GIMP with a Photoshop boxout, and vice versa, to see which is most popular.

Headphone Heaven

In the April magazine, you did a headphones comparison, titled "Battle of the Cans." Very good article. Looking at your reviews, I decided to buy the Audio-Technica ATH-M50X headphones for myself, because the price of $120 sounded good for great set of headphones. However, I went to the Audio-Technica website, and the list price was $239. What gives, and why is there a $100 difference? Can you tell me where you found the price, because I would like a pair at this price?

–Victor Viola

STAFF WRITER ZAK STOREY RESPONDS: It's always a bit of a problem when it comes to pricing in the magazine. The idea is that we include the manufacturer's website URL, in case you have any support issues, or are after some extra info, and then we go out and try to find the best deals we can for the product we're reviewing elsewhere, because manufacturers tend to charge more directly. It's a bit awkward, but it does mean it reflects real-world pricing, as opposed to recommend pricing. Most of the prices we pick come from www.newegg.com or www.amazon.com. In the case of the ATH-M50Xs, you can buy them from Amazon for $125 (at time of writing) by pointing your browser at: http://amzn.to/28Nxexr.

PSUs, Viruses, & More

I am a regular reader of *Maximum PC*. I like to buy my hardware based on your round-up articles. I see that you've had a lot of round-up articles about SSDs, CPUs, routers, and so on, but it seems you've never had any articles about PSUs. When do you plan to include one? Last year, you didn't have any articles about antivirus software, either. Will you have any in future issues?

My final question: Is a Noctua NHU12S good enough to handle a Core i7 5820K or 5930K, overclocked

↘ submit your questions to: comments@maximumpc.com to 4.2–4.3GHz, or even a 5960X to 4–4.1GHz? Or is it better to use a NHU14S?

–Monica Ha Tran

EXECUTIVE EDITOR ALAN DEXTER AND STAFF WRITER ZAK STOREY RESPOND: Power supplies are notoriously difficult to test properly. They require specialist hardware that needs servicing regularly and costs a fortune to buy in the first place. On top of that, there are still cases where such testing can miss problems with a particular PSU build, which ultimately leaves you feeling that testing isn't worth the considerable amount of time and effort it involves. Our recommendation for PSUs is to go with a big brand name that has a good warranty.

We haven't run an antivirus round-up in the last year, either, although this is for a completely different reason. Basically, the days of being able to buy a single suite that would protect everything you do online are behind us. While antivirus software still has a place in everyone's arsenal, protecting yourself online now needs to include lots of other things, as well. Next issue, we'll look at the best way of protecting yourself in this modern world.

On to your final question: Generally speaking, both the NHU14S and the NHU12S would be fine handling those cores at stock, but the excess heat output from ramping up those processors—the 5960X in particular—would be a serious cause for concern.

As far as air coolers go, we suggest going with either a Noctua NH-D15, or something perhaps like Be Quiet's Dark Rock Pro 3 instead; certainly if you're looking into overclocking either the 5820K or 5930K.

On to the 5960X: While recently re-benchmarking it for our 6950X review, we noticed that when we cranked the voltage up to 1.3V to get our 4.3GHz overclock, we saw temperatures up at around 85 C, and that was on our Kraken X61 280mm AIO cooler, which has a far larger footprint than either of those two towers we just suggested.

Guns & Ammo

In Mr Griliopoulos's review of *Tom Clancy's The Division* (June 2016), he incorrectly referenced "clips" instead of magazines when talking about taking down named bosses. It's a common mistake, so I wanted to clarify for him to prevent future miscommunications to your readers.

Googling "magazine vs clip" gives more examples, but see https://s-media-cache-ak0.pinimg.com/236x/ca/1e/31/ca1e3137cc5f440775eec5e:7d872b9d6.jpg.

Thanks for your hard work on the magazine (I've been subscribing ever since middle school)!

–NS

REVIEWER DAN GRILIOPOULOS RESPONDS: I deserve a clip around the ear for that one.

This Is a RAID

Renounce your support of RAID 5, or I'll stop my subscription post-haste, and make a huge-ass stink about it. I've been subscribing pretty much since 1999. You guys need to get with the times. If you can have a dude write about Linux, you can drop the dead-end that is RAID 5. Or can you?

–Ben Pearman

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We thought we were making progress when we managed to stop Zak thinking RAID 0 was the only way to go. It's all down to what you use the machine for, of course, and for many readers, RAID 5 isn't quite the evil you portray. However, you are right that there are problems with RAID 5 for more serious uses, and it's something that we do intend to look at in more detail in a future issue. Until then, can we all ensure we have a good backup regime in place?

Beautiful Pi

Thank you for your inclusion of the Raspberry Pi article by Mayank Sharma in your May issue. I was introduced to the Raspberry Pi by your magazine a year ago, and immediately pursued the idea of teaching computer programming to our 5th-through-8th-grade students. We purchased the Pis and added the class to our 2015-2016 curriculum, using Carrie Anne Philbin's *Adventures in Raspberry Pi* as our guide/text. The results were incredible. I actually don't know who had more fun—me or the students. The kids loved the class to the point that we had to push them out of the classroom at the end of the hour. They didn't want to leave! They're now fluent in Scratch, and capable of doing better-than-average programming in Python. We plan to continue down this path using the Pi as the base for a robotics class in the coming school year. That being the case, I'm looking forward to future Raspberry Pi articles by Mayank. Keep up the good work!

–John Kunkel

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: It's good to hear you're enjoying the tutorials so much, and that you're doing your own bit to get kids coding again. We've got plenty of Raspberry Pi tutorials planned for the future, so we'll keep doing our bit to help get the younger generation interested in computing, too. As ever, if anyone has any ideas they'd like to share on this front, drop us a line.

[NOW ONLINE]

$400 HDK 2 VR HEADSET

Razer and Sensics, the two companies that are spearheading the Open Source Virtual Reality (OSVR) movement, just announced a second-generation VR headset with an upgraded display, which is supposedly on par with the Oculus Rift and HTC Vive. It's also several hundred dollars cheaper, with an MSRP of just $400. "The HDK 2 allows us to meet the needs of VR fans and gamers, and provide developers with affordable open-source hardware to innovate with," says Christopher Mitchel, OSVR Lead, Razer.

You can read the full story online at http://bit.ly/28NDGmS.

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THE BUILDS

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INGREDIENTS

PART		PRICE
Case	Thermaltake Core V1 **NEW**	$48
PSU	Corsair CS550M	$80
Mobo	ASRock H170M-ITX/ac	$95
CPU	Intel Core i5-6500	$205
GPU	Sapphire Radeon R9 380 4G **NEW**	$205
RAM	8GB (2x 4GB) G.Skill Aegis DDR4-2133	$32
SSD	240GB SanDisk Ultra II 2.5-inch SATA	$71
HDD	1TB Seagate Barracuda 7,200rpm 3.5-inch SATA	$60
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $812

NOT MUCH HAS CHANGED in this build, as at the time of writing, we're still waiting on AMD's RX 480 to hit retail. That means the R9 380 stays on, though we changed it up for Sapphire's factory overclocked model. Changing up the video card presented problems in the little Cougar QBX. As much as we love the case, it can be cramped, and puts restraints on the size and type of GPU and PSU you can use. We decided to change it to allow a little more flexibility. Thermaltake's Core V1 is a great inexpensive mini-ITX case. All four of its side panels are removable and interchangeable—great for customizing cooling or viewing arrangements. One thing we really like is that the case features a cutout in the front of the frame, which offers an extra inch or two for longer GPUs. Installing the system is easy, too, as it has a horizontal layout. The mobo tray sits above the PSU compartment, which makes installing RAM, your CPU, and your GPU a breeze.

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro M	$90
PSU	EVGA SuperNOVA G2 650W 80 Plus Gold	$80
Mobo	Gigabyte GA-Z170X-Gaming 5 **NEW**	$160
CPU	Intel Core i5-6600K	$245
Cooler	Corsair H80i v2	$87
GPU	MSI Nvidia GeForce GTX 1070 8G OC **NEW**	$430
RAM	16GB (2x 8GB) G.Skill Ripjaws V Series DDR4-2400 **NEW**	$60
SSD	250GB Samsung 850 EVO M.2 **NEW**	$95
HDD	Western Digital Black Series 1TB 7,200rpm	$74
OS	Windows 10 (*Download*)	$110

Approximate Price: $1,431

LAST MONTH, we only had GTX 1070 Founder's Editions available. Now, we're starting to see different models from add-in board or AIB partners, such as Gigabyte and Asus. We went with MSI's Twin Frozr cooler design. Twin Frozr cards offer great performance out of the box, but as with most aftermarket designs, they like to dump hot air into your case, rather than push it out like a reference blower design (read: Founder's Edition) does. It's not a big deal if you've got good air flow, though. We also changed our motherboard. Gigabyte's Z170X-Gaming 5 is only $5 more than last month's Asus Z170-A. It features dual M.2 slots for SSD storage without the mess. Speaking of M.2, prices for Samsung's M.2 850 Evo fell back down to near parity with the 2.5-inch drives—just $4 more. That's enough to warrant a switch to M.2, as it means one less cable. While the Gigabyte mobo supports NVMe, NVMe drives still remain too rich for our blood at this price tier.

TURBO

THE GTX 1080 IS, without a doubt, the fastest consumer graphics card you can buy right now. So we asked ourselves: Why have just one, when you can have two? Our Turbo build is generally geared with SLI in mind, so we felt we needed to double up on GTX 1080s. The frustrating thing about doing so is that the GTX 1080 Founder's Edition was still hard to find in stock at the time of writing. We're hoping that inventory won't be so impacted by the time you read this. To make room in our budget for the twin 1080s, we had to scale back our memory and storage. We dropped from 32GB to 16GB of memory, but we were able to get 3,000MHz sticks instead of 2,400MHz. We also dropped the twin 1TB Samsung 850 Evos in favor of spinning hard drives. We were able to keep the 512GB 950 Pro in the build, so the extra storage can often feel more like icing on the cake than a real necessity. Although we only have the budget for two GTX 1080s, bear in mind that Nvidia only supports two-way SLI out of the box, due to the use of the high-bandwidth SLI bridge. Nvidia warns that going three-way will sharply diminish returns on SLI performance.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

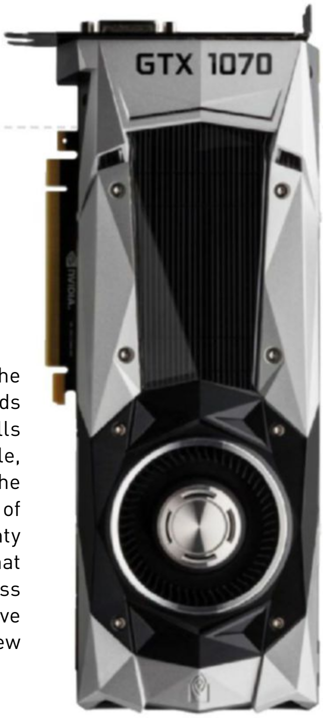
INGREDIENTS

PART		PRICE
Case	Cooler Master MasterCase 5	$105
PSU	EVGA SuperNOVA G2 850W	$130
Mobo	MSI X99A SLI Plus	$230
CPU	Intel Core i7-5820K	$390
Cooler	Corsair H100i v2	$98
GPU	2x PNY Nvidia GeForce GTX 1080 Founder's Edition **NEW**	$1,400
RAM	16GB (4x 4GB) G.Skill Ripjaws 4 Series DDR4-3000 **NEW**	$90
SSD	512GB Samsung 950 Pro M.2 (NVMe)	$320
HDD	2x 1TB WD Black 7,200rpm 3.5-inch SATA **NEW**	$128
OS	Windows 10 (*Download*)	$110

Approximate Price: $3,001

UPGRADE OF THE MONTH

GEFORCE GTX 1070



The GTX 1070 is by far the best buy for video cards right now. While it falls behind the GTX 1080 a little, it still outperforms all of the consumer Maxwell line of cards, including the mighty Titan X. And all of that performance costs you less than what you would have paid for a GTX 980 just a few months ago.

$430, www.nvidia.com

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